Theoretical Study on Nematic Liquid Crystalline Ordering in Thin Confined Systems

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1. Introduction

An order of nematic is generally soft and reacts sensitively to an external field and also is affected to a condition of boundary walls which confine the liquid crystal.   The direction of the order is changed by an electric field under suitable anchoring condition due to walls, and competition between both agents is applied to liquid crystal displays.   Therefore, it is important to understand how the ordering and direction are controlled by anchoring conditions.

In this thesis, nematic crstalline ordering in thin confined systems under various type of anchoring conditions are investigated in the framework of the Maier-Saupe model based on statistical mechanism method.   In order to clarify the mechanism of continuous change of phase, non-uniformity due to boundary effect is described in terms of effective filed which is conjugate to the order parameters, and behavior of the system is analyzed by observing loci of the effective fields on the phase diagram of the bulk.

2. Namatic ordering in a homeotropic cell

The nematic ordering in a thin system under the homeotropic anchoring condition is studied.   As the system that correspondent to the homeotropic system, the surface molecule orientation that fixed into a wall surface normal was introduced. The first order transition disappears and continuous change of phase occurs in the system with thickness smaller than a certain critical thickness.   The mechanism of this continuous change occurring at the thickness just smaller than a critical thickness is disclosed; a metasteble high-temperature phase changes to a metastable low-temperature one continuously via an unstable phase between them.   On the other hand, at the extremely thin system, the effective fields do not cross the transition line nor the bound lines of the metastable states and move in an analytic domain, and the system undergoes the usual continuous change.

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3. Nematic ordering under external fields

Another type of anchoring wall, that is the state in which the molecule aligns to a substance in parallel is studied. The bulk systems under external field corresponding to this are nematic phase having negative magnetic anisotropy. So, nematic phase transition with both uniaxial and biaxial order parameters is studied in the two kind of external fields where are conjugate to the order parameters, respectively. Figure 1 shows a global phase diagram on the fields versus temperature space is obtained first in the mean field theory, which is similar topologically to the phase diagram of the three-state Potts in three dimensions. Based on this diagram, the ordering phenomenon in the system with planer anchoring walls is predicted, where the first order phase transition changes to the second order one as the thickness of the system becomes small.
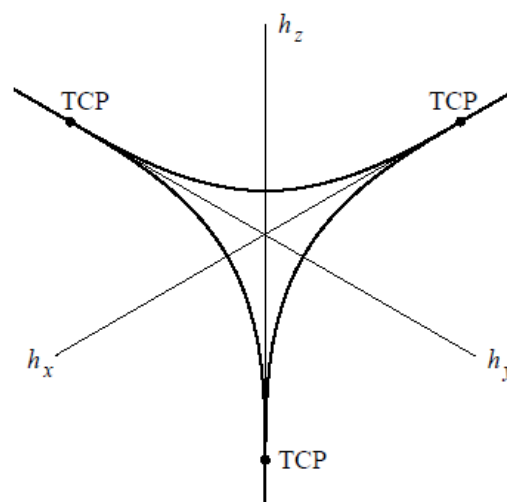
Fig. 1 Phase diagram on the oblique h_x - h_y - h_z plane. TCP is the tricritical point.

4. Effects of Biaxial Anchoring Wall on Nematic Ordering

Nematic Ordering in the system with biaxial anchoring walls are investigated as the correspondent to a bulk nematic system exposed two kinds of external fields. The analyses are carried out in the framework of the mean field theory. The wall condition is given by a probability density function of the long axis orientation of molecule on the wall and by a parameter denoting strength of interaction between a nematic molecule and a molecule on the wall. And Landau unfolding method was used in this study to do a numerical calculation simply. It is shown that the biaxial order suppresses the uniaxial order and the crossover between the homeotropically and homogeneously anchored phases is proved to occur under the condition which is strictly similar to that at bulk in the fields. Also, when the interaction of molecule on wall was strong, it is shown that a wetting phenomenon is caused even under biaxial walls.

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A Study of Positive Active Materials for Lithium Ion Rechargeable Battery

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1. The objective of this study

The objective of this study is to characterize the positive active materials for lithium ion rechargeable battery and to identify the relationship between the properties and the electrochemical performances, and to bring these results to develop the excellent materials.

2. Summary

【Spinel Li-Mn-O materials】 $Li(Mn_{2-x}Li_x)O_{4-\delta}$ have been extensively studied for cathode material in large capacity rechargeable Li-ion batteries for EV. However, it has large capacity fading upon charge and discharge cycling. It is important to clarify the mechanism of capacity loss in order to improve the cycle life. Oxygen nonstoichiometry of $LiMn_2O_{4-\delta}$ has been reported, however, only qualitative relationship between the cycle life and oxygen deficiency ' δ ' has been reported so far. Therefore, the quantitative details of relationship between the cycle life and the oxygen deficiency were studied. δ was precisely determined by chemical analysis. The capacity retention is linearly decreased with increasing δ. The changes in lattice parameter at the end of discharged state after the cycle depended on δ. They were in good accordance with the degradation in the low voltage region of potential curve, which was strongly affected by oxygen loss and rapidly saturated within about the 100th cycle. These results implied the influence of Jahn-Teller ion Mn^{3+} introduced with oxygen deficiency.

In addition, the mechanisms of manganese spinels dissolution and capacity fade at high temperature were studied. Tests on the stability of spinels stored at different states of charge were performed. Mn dissolution took place irreversibly from the charged state with formation of MnF_2, ramsdellite-$Li_{0.5}MnO_2$. In the discharged state, the Mn at the surface of the $LiMn_2O_4$ was in equilibrium with a soluble species, which leads to an increase in the cathode resistance. The amount of the dissolved Mn increased with increasing $LiPF_6$ concentration and that 2 equiv. of $PO_2F_2^-$ were generated. Concurrent formation of carbonate decomposition products suggests the mechanism of Mn dissolution from the charged state was composed of three steps as shown in Fig. 2.
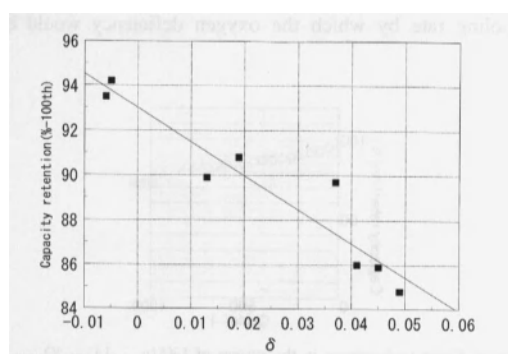

Fig. 1. The relationship between oxygen deficiency δ and capacity retention rate after the 100th cycle.
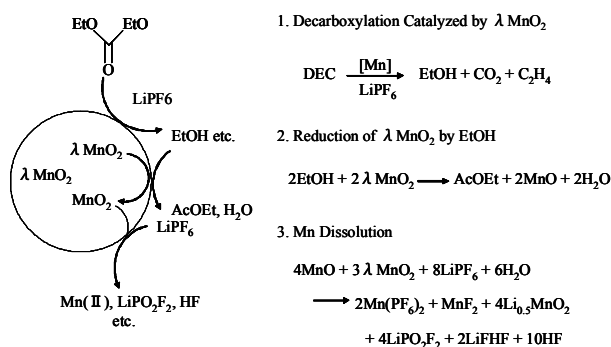

Fig. 2. Proposed mechanism of Mn dissolution from λMnO_2.

【Layered Li-Ni-O materials】 The effect of CO_2 on layered $Li_{1+z}Ni_{1-x-y}Co_xM_yO_2$ (M = Al, Mn) materials was studied. $Li_{1+z}Ni_{(1-x)/2}Co_xMn_{(1-x)/2}O_2$ (Ni/Mn = 1) singularly exhibit high storage stability. On the other hand, $Li_{1+z}Ni_{0.80}Co_{0.15}Al_{0.05}O_2$ were very unstable. The surface of CO_2-treated sample is overspread with passivation which might be Li_2CO_3. The relationship between degree of carbonation and cell performance revealed the discharge capacity was not decreased and the capacity retention was improved during the consumption of excess lithium 'z', and then deteriorated rapidly above 'z' in $Li_{1+z}Ni_{0.80}Co_{0.15}Al_{0.05}O_2$.

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【Layered Li-Ni-Mn-Co-O materials】 $Li_{1+y}Ni_xCo_{1-2x}Mn_xO_2$ materials were characterized by various methods. The cell performance depended on the composition. The rate performance deteriorated as Co content decreased, and improved as excess Li content increased. The change of cell performance associated with composition variations was closely related to both the cation mixing (structural disorder) and the volume resistivity (electrical conductivity). The degree of cation mixing depended greatly on Co content, and the volume resistivity depended greatly on excess Li content.
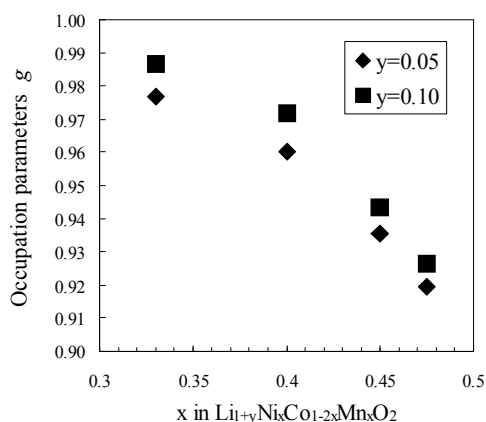

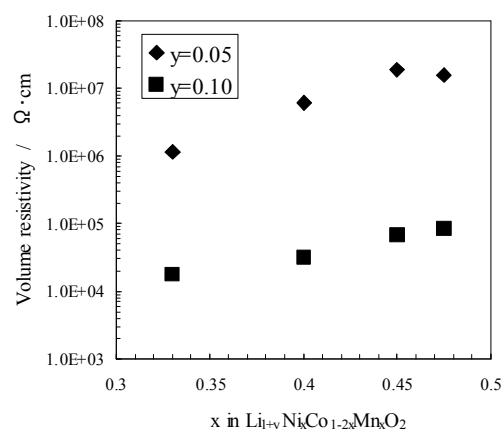Fig. 3. Relationship between composition and occupation parameter g(Li) for $Li_{1+y}Ni_xCo_{1-2x}Mn_xO_2$ (y = 0.05 and 0.10).

Fig. 4. Relationship between composition and volume resistivity for $Li_{1+y}Ni_xCo_{1-2x}Mn_xO_2$ (0.33 $\leq$ x $\leq$ 0.475, y = 0.05 and 0.10).

X-ray absorption fine structure on layered Li(Ni, Mn, Co)O_2 materials was studied. This study revealed that Li contributes to the rate capability through the concentration of Ni^{3+} in the transition metal layers, which is closely related to the volume resistivity of the material. On the other hand, Co contributes to the Li-ion conductivity through the less cation mixing rather than to the electronic conductivity of the pristine powder.

The electrochemical analysis of $Li_{1+y}Ni_{5/12}Co_{1/6}Mn_{5/12}O_2$ (y = 0.04, 0.13) materials was performed to elucidate how the change of the volume resistivity of the pristine powder contributes to the cell performance. Electrochemical impedance measurements indicated the charge transfer resistance decreased with increased excess Li content 'y'. The equivalent circuits' model considering the volume resistivity was proposed.

【Li-Cu-Ni-O materials】 The solid solution materials between Li_2CuO_2 and Li_2NiO_2 were studied with respect of the electrochemical performance and the crystal structure. Pure Li_2CuO_2 shows only 100 mAh/g of capacity, but nickel substituted compositions delivered reversible capacity of 250 mAh/g corresponding one equivalent of lithium. The enhancement of reversible capacity is attributed to the stability of Ni^{3+} state compared to Cu^{3+}. Li_2CuO_2 undergoes phase change to monoclinic during lithium deintercalation, while the nickel-rich compositions show a new phase different from either original orthorhombic or monoclinic structure. The latter phase shows two-step voltage profile at 2 and 4 V. The middle composition in the solid solutions, e.g. $Li_2Cu_{0.6}Ni_{0.4}O_2$, indicates high capacity and high resistance against the structural degradation under high rate lithium intercalation.

3. Concluding remarks

The present study has identified the relationship between the properties and the electrochemical performances about the positive active materials, and brought these results to develop the excellent materials.

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Estimation, Parameter Learning and Prediction of Time-Varying Communication Channels

Gagik Mkrtchyan †

Keywords: Digital communication systems, time-varying signal propagation channels, inter-carrier interference cancellation, channel estimation, dynamic parameter learning, model-based prediction.

1. The purpose

The aim of this research is feasibility study of high data rate communication in time varying signal propagation channels. The targets of research are the effective inter-carrier interference cancellation method and provision of the estimation, dynamic parameter learning and prediction of time varying channel response.

2. The related prior arts

There is the known bound for communication systems performance, but that bound is mostly unattainable because of the channel response knowledge error and the interference in time varying channels. The time varying channel response estimation is required for many wireless communication systems because of the user mobility. In some mobile wireless applications, such MC-CDMA, the precise channel estimation is not satisfactory and each user must predict the uplink channel response in the time varying fading channel. The main problem of linear regression based prediction methods is the requirement of the channel's statistics knowledge, or otherwise the large number of known data transmission (pilot symbols or pilot tones) must be done for the precise calculation of the statistical characteristics, which leads to the significant loss of the communication efficiency. The inter-carrier interference (ICI) can become the strong degradation factor for channel estimation and data detection, due to the carrier frequency offset and Doppler frequency spread. While the problem of the carrier frequency offset is comparatively unsophisticated and has multiple suitable methods for the offset correction; the ICI caused by Doppler spread has very complex representation and there is no fully satisfying solution. The ICI occurs because when using IDFT, the spectral density function of n-th subcarrier is zero on the frequencies of all other subcarriers, but it is not zero even very near to them.

3. Proposed methods abstract

This research provides the detail representation of the temporal and spatial characteristics of the time varying channel models. The employed in this thesis dynamically quantized parameter based models describe the time varying channel by limited number of parameter set, which are assumed to be constant during some quantized period of the time, but has random behavior from one time step to another transition. The transition between sets of the parameters depends only from the previous state of the parameters by the Markov chain rule, and the statistics of the time varying channel model is given by the transition probabilities. The conventional preamble symbol based channel estimation methods calculate the channel response separately for the each of preambles and then use linear and nonlinear interpolation for channel response calculation during the data symbols, transmitted between them. In this research is employed a different approach, based on the quantized limited number of the channel parameters, so the received information from the multiple preamble symbols is directly combined for maximum likelihood (ML) channel estimation results calculation.

The conventional pilot tones based channel estimation, widely used in the orthogonal frequency division multiplexing (OFDM) and the multi carried code division multiple access (MC-CDMA), employs the orthogonality of subcarriers for separate sub channels responses estimation and then linearly or nonlinearly interpolates the response through the whole communication channel. This method has two drawbacks for time varying channel: it suffers from introduced inter carrier interference (ICI) and it has a loss of the estimation precision during the interpolation. For solution of these problems in thesis is proposed the time domain correction of the subcarriers to reduce effect of ICI and frequency-time domain estimation for improving the

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precision. In many of the wireless communication systems it is not only required the precise channel estimation but also it's near future prediction. For example the orthogonality of the MC-CDMA uplink transmission can be ensured only by means of the pre-equalization, and for the time varying channels the pre-equalization coefficients must be predicted using the estimation results of the downlink. In this thesis the quantized model based prediction approach is provided, which doesn't use the knowledge of channel statistics. The conventional methods based on the Wiener, Kalman or other filtering techniques need the channel response's autocorrelation knowledge, which is not known for the most of the practical propagation channel conditions..

The final part of the thesis is dedicated to the time varying channel's parameters dynamic learning. Due to the strong tendency to the unification of the mobile communication systems, the software-defined radio (SDR) with reconfigurable signal processing devices becomes the new standard for future generation of the wireless communication systems. SDR requires the learning of the multiple unknown parameters to realize the potential capabilities of the cognitive communication. The dynamic learning of the time varying channel parameters is valuable for SDR because it doesn't employ any knowledge about temporal and spatial characteristics of the propagation paths distribution. The dynamic parameter learning can be executed by means of the evolutional algorithms in combination with the complex weighted neural networks. Evolutional algorithms are optimal multi dimensional search techniques, and are well known as the effective methods for the parameter learning. Evolutional algorithms can be conditionally divided into the three categories: evolution strategies, genetic algorithms and evolutionary programming. While the neural networks and genetic algorithms were widely used for the time invariant channel response learning, they were not applied to the time varying channel's parameters learning. The problem actually was that both pure neural networks and genetic algorithms couldn't be directly applied to the time varying conditions because the convergence time is too long and small fluctuation can create the chaotic behavior. In this thesis is proposed the usage of the evolutional strategy based method instead of the genetic algorithm. The proposed method controls the fit result of the nonlinearly dependent parameters by means of the choosing the principal components from both of the parents during the "crossover" and keeps the "elitism" of the "population set" by means of introducing the minimal "learning and crossover ages". The complex weighted neural networks, which are employed for learning of the propagation paths amplitudes, are simplified to the single layer perceptrons with the linear activation functions. This allows employing of the direct error gradient based learning of linear parameters, which decreases the number of the required learning steps and is more robust to the fluctuations due to the noise. The convergence problem is solved by the separation of the dynamic learning process for the nonlinearly and linearly dependent parameters. The first is realized by means of the evolutional algorithm, while the second is realized by means of the complex weighted neural network.

4. Concluding remarks

Unfortunately the degradation of data communication performance in time varying channels is inevitable, and all the channels are time varying to a greater or less extent. But in the most of the actual cases it is possible to strongly minimize the degradation effect if precisely to know channel response dependence in time. This thesis proposed the novel methods of ICI cancellation, dynamic learning and prediction of channel.

1) The proposed time domain signal form correction method can effectively compensate the ICI without significant increase of the signal processing complexity and is applicable up to the very high vehicle mobility.

2) Next contribution of the thesis is in the time varying channel's parameters learning by means of the adaptive quantization and the model based prediction of time varying channel, which allows compensation of the MUI in the uplink transmission of TDD MC-CDMA systems.

3) The finally proposed dynamic learning method combines the complex weighted neural networks with evolutionary learning algorithm for simultaneous learning and prediction of channel response, and it provides good accuracy for nearly ideal compensation of the degradation due to the time varying channel.

5. Publications

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Study on Improvement and Application of Titanium Dioxide–Based Photocatalysts

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1. Introduction

Semiconductor-based photocatalysts which create electrons and holes by absorbing light have been applied to the design of environmental photocatalytic systems and dye-sensitized solar cells (DSSC). TiO$_2$ has been extremely focused on its variety of applications, because it shows a number of attractive characteristics such as high photoreactivity, low cost, non-toxicity and chemical stability. Recently, many attempts have been made to improve and apply of titanium dioxide-based photocatalysts.

In this research, it was aimed to prepare an improved photocatalyst based on the titanium dioxide by using the sol-gel method under the environment-friendly condition, and to evaluate their photocatalytic activity. In addition, visible-light-driven TiO$_2$ thin films were applied to a dye-sensitized solar cell system.

2. Adsorption and Photocatalytic Characteristics of Activated Carbon Made from TiO$_2$-Coated Woody Waste

Composite powder materials consisting of activated carbon and TiO$_2$ were prepared through the carbonization of woody waste powders coated with TiO$_2$ gel by using the sol-gel method. The effect of the conditions for preparing TiO$_2$ sols and the carbonization process on the properties of the resulting composites was examined. It was found that the addition of diethanolamine (DEA) to the TiO$_2$ sol was effective for achieving a smooth coating on woody waste-derived activated carbon. The composites obtained by heat-treating the wood powders coated with DEA and polyethylene glycol (PEG)-added TiO$_2$ gel with at 530 $^\circ$C and 700 $^\circ$C exhibited both the adsorption and the photocatalytic decomposition of methylene blue in water.

3. Preparation of Visible-Light-Driven Photocatalysts by Sol-Gel Method and Their Photocatalytic Activity

The Pr-doped photocatalytic thin films were prepared by the sol-gel method. The photocatalytic activity of the films under visible light irradiation was evaluated.

(1) Doping of Pr was very effective to shift the absorption edge of TiO$_2$ thin film toward the long wavelength. This means that the absorption edge shift toward visible wavelength side in the Pr-doped TiO$_2$ thin film, probably through the formation of an impurity level due to Pr^{3+} or Pr^{4+} in the band gap. For degradation of methylene blue solution, the Pr-doped TiO$_2$ thin film showed excellent photocatalytic activity under visible light (>400nm) irradiation, especially in the range of 400-500nm, while TiO$_2$ thin film showed no activity under the same condition (Fig.1). In other words, it was found that Pr-doped TiO$_2$ thin films acted as visible-light-driven photocatalyst.

（2）Pr-doped titanophosphate glass thin films were prepared by the sol-gel method. Under full arc irradiation of Xe lamp, the photocatalytic activity was observed for all samples. But, under visible light irradiation of Xe lamp, it was only seen for Pr-doped samples.

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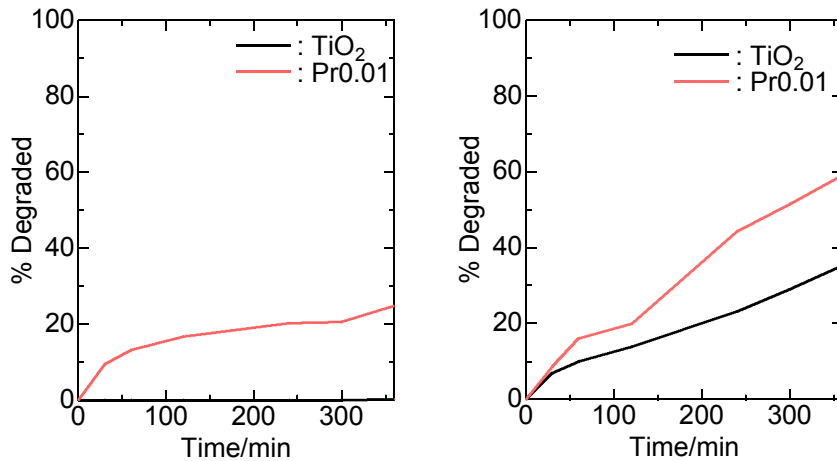
Fig.1 Photocatalytic activity of Pr-TiO₂ film under visible light（λ ＞ 400 nm） irradiation of Xe lamp.

4. Reduction of Mite Allergen Activities by Photocatalytic Treatment with Titanium Dioxide for a Cleaner Indoor Environment

The reduction of mite allergen activities by photocatalytic treatment with titanium dioxide (TiO_2) was investigated for a cleaner indoor environment.　Degussa P25 TiO_2 and recombinant Derf 1 protein were used as the photocatalyst and the mite allergen, respectively.　With increasing the amounts of photocatalyst, the rate for the reduction of allergen activities increased gradually.　At the irradiation time of 60 min, the reduction efficiencies of allergen activities were more than 96.9%, when the photocatalyst TiO_2 of more than 1 mg was used.　As a consequence, the photocatalytic treatment with TiO_2 was very effective for the reduction of allergen activities.　Since aspartic acid and glycine concentrations increased during the initial degradation, the destruction of amino acid may become a main reason for the reduction of allergen activities by the photocatalytic treatment.　The photocatalytic treatment for the reduction of allergen activities is simple, easy handling and low cost.

5. Application of Visible-Light-Driven Pr-Doped TiO₂ Thin Films to a Dye-Sensitized Solar Cell System

Since it has been expected that absorption in a visible region by the Pr-doped TiO_2 layer was effective to enhance the conversion efficiency of dye-sensitized solar cell (DSSC), the photovoltalic properties of the Pr-doped TiO_2 thin film were evaluated for the DSSC system under the simulated sun light.

As a consequence, the light conversion efficiency (η) of DSSC using the Pr-doped TiO_2 thin film was 1.07%, although the efficiency was 0.71% for DSSC using the pure TiO_2 thin film.

6. Conclusion

In the present study,　an improved　TiO_2 photocatalyst were prepared by using the sol-gel method under the environment-friendly condition.

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Investigation of novel asymmetric reactions and synthetic study of a gastrin receptor antagonist, AG-041R

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(Organic chemistry, Chemistry for materials)

1. The purpose

The aim of the research is to establish an efficient synthetic route for the novel anti gastrin agent AG-041R **1**, which has a tetra-substituted chiral center in the structure. The synthesis has to meet the requirement for the manufacturing cost and scalability, therefore efficient construction of the chiral center was investigated.

2. The substantiation of the synthesis

The approach taken for the retrosynthetic analysis (Scheme 1) revealed that a strategy based on the alkylation of the oxindole derivatives would be the most straightforward in order to obtain the basic framework of our target compound. From the outset it was realized that one of the synthetic challenges would be the asymmetric alkylation of oxindole derivative **2**. Therefore, the focus was on identifying an efficient method for the asymmetric alkylation reaction.

Asymmetric alkylation using a phase transfer catalyst is one of the choices for construction of the tetra-substituted chiral center. However, this method still requires a relatively large amount of chiral catalyst, which has a complicated structure and is difficult to obtain.

Due to availability and ease of control of the reaction process, it was decided to investigate the stoichiometric alkylation of oxindole enolates with haloacetic acid esters using a commercially available chiral alcohol such as *l*-menthol as an auxiliary. Reaction of this type has rarely been studied to date, even though a substantial amount of effort in using *l*-menthol as a chiral auxiliary has been demonstrated. To the best of our knowledge, only a single report has been published in which poor stereoselectivity was shown in the alkylation of oxindole derivatives with *l*-menthyl chloroacetate as a chiral electrophile.

SCHEME 1. Retrosynthetic Analysis

3. The results of the asymmetric reaction

The alkylation reaction of urea **2** proceeded efficiently in aprotic polar solvents such as DMF and DMSO and the racemic AG-041 was synthesized from the alkylation of urea **2** with 2-bromo-N-*p*-tolylacetamide, and so we first tried the alkylation reaction with *l*-menthyl bromoacetate in DMF. The resulting diastereoselectivity of the reaction was low (Table 1, entry 1). Even at lower temperatures in DMF, only a slight degree of improvement in the stereoselectivity was observed (Table 1, entries 2 and 3). By using solvent THF, the selectivity showed a slight increase with *t*-BuOK as the base (Table 1, entry 4). When the reaction was performed in a less polar solvent with a lithium cation base, the
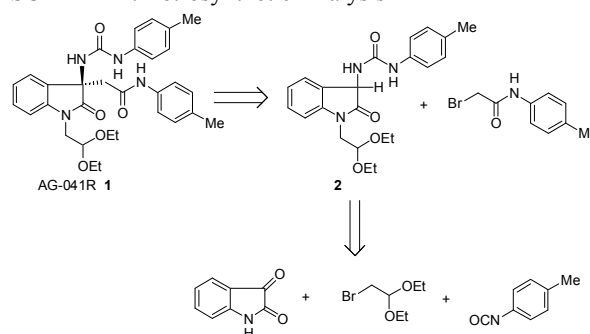
TABLE 1. Diastereoselective Alkylation of the Urea 2

Entry[a]	Solvent	Base	Equiv of base	Temp. (°C)	Ratio (**9**:**10**)
1	DMF	*t*-BuOK	1.1	-10	60:40[e]
2	DMF	*t*-BuOK	1.1	-60	75:25[e]
3	DMF – Toluene	*t*-BuOK	1.1	-78	80:20[e]
4	THF	*t*-BuOK	1.1	-10	75:25[e]
5[b]	THF	LiHMDS	1.0	20	90:10[e]
6[b, c]	Dioxane	LiHMDS	1.0	20	92:8[e]
8	THF	LiHMDS	1.0	0	92:8[f]
9	THF	LiHMDS	1.1	0	93:7[f]
10[d]	THF	LiHMDS	1.2	0	94:6[f]
11	THF	LiHMDS	1.1	-15	94:6[f]

[a]Unless otherwise noted, the reaction was carried out with 1.2 equiv of *l*-menthyl bromoacetate. [b]1.1 equiv of *l*-menthyl bromoacetate was used. [c]LiHMDS in hexane was used. [d]1.3 equiv of *l*-menthyl bromoacetate was used. [e]Determined by ¹H-NMR analysis of the crude reaction mixture. [f]Determined by HPLC analysis of the crude reaction mixture.

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diaresteoselectivity was greatly increased even at rt (Table 1, entry 5). Although dioxane showed the best results in terms of diastereoselectivity for the reaction (Table 1, entry 6), it requires special handling because of its possible carcinogenic activity. Therefore, THF was selected for further study. The diastereoselectivity increased when the reaction was performed at lower temperature (Table 1, entry 8) and was improved by the use of a slight excess of base (Table 1, entries 9 and 10).

Finally, we selected the reaction conditions shown above (Table 1, entry 9) for further scale-up. We have successfully performed the reaction on a scale of 100 g with a 91.8:8.2 diastereoselectivity ratio. Recrystallization of the crude product from a methanol/water solution gave a diastereomerically pure product in 55% yield.

The transformation from the menthyl ester **3** to the final compound **1** was performed by the hydrolysis and amidation by using EDC-HCl as a coupling agent, the efficient total synthesis was achieved (Scheme 2).
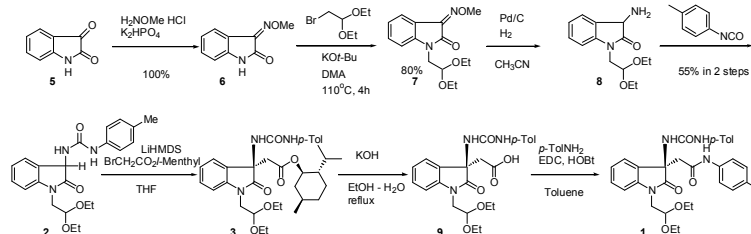
SCHEME 2.

FIGURE 1. *l*-Menthyl Bromoacetate

4. Stereochemistry of the reaction

From the results shown in Table 1 and because the use of a more coordinatable lithium base gave the best stereoselectivity, there is possible coordination of *l*-menthyl bromoacetate with the lithium enolates at its carbonyl group in the transition state. In the most stable conformer of the *l*-menthyl bromoacetate the carbonyl group should be directed downward as depicted in Figure 1, which suggests that the oxindole enolates should approach from the down side of the conformer coordinating with the lithium cation, and thus the approach of the enolates from the upper side would be eliminated. And the results with the other type of oxindole derivatives indicate that the carbonyl group in the nitrogen protective group of the oxindole enolates should participate in the coordination with the lithium cation. Based on these results, the two transition states shown in Figure 2 are possibilities. Of the two, transition state A is preferable due to the steric interaction between the isopropyl group in the *l*-menthyl group and the nitrogen protective group in transition state B.
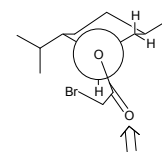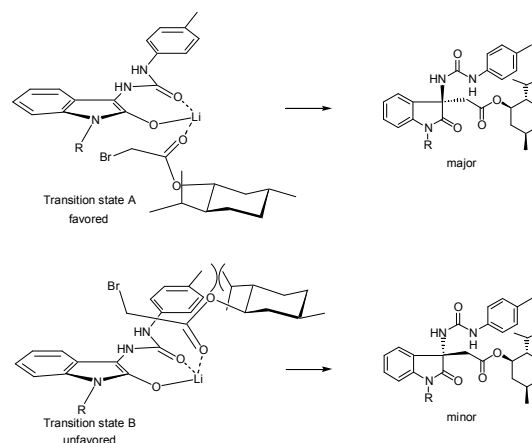
FIGURE 2. Plausible Favored and Unfavored Transition States

5. Conclusion

A highly efficient asymmetric alkylation of oxindole derivatives has been demonstrated by using commercially inexpensive *l*-menthol as a chiral auxiliary. The use of lithium cation is essential for the high diastereoselection. A six-step chromatography-free synthesis of the optically pure oxindole derivative **1** was successfully achieved by the finding of the diastereoselective reaction in overall yield of 26%.

Author's publication

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Fundamental Research on Mechanical Evaluation of Cardiac Function Using Numerical Simulation

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1. Introduction

It is extremely important to estimate quantitatively the mechanical functions of the left ventricle from a viewpoint of the medical diagnosis of heart disease. In order to estimate the ventricular functions, the authors have constructed a fundamental numerical simulation system based on a finite element ventricle model connected with both an electric stimulus transmission model and a blood circulation system model.

2. Mathematical model of left ventricle and finite element simulation

The mathematical models of the left ventricle are composed of the mechanical model of the myocardial fiber, the electric stimulus transmission model and the blood circulation system model. The myocardium consists of numerous contractile muscle fiber elements called "sarcomere" which produce an active tensile force and contract by themselves after receiving the electric stimulus sent from the so-called pacemaker of the heart. The magnitude of active tensile force produced by the sarcomeres may be approximated through a set of simple relations proposed by Beyar and Sideman. The relationships of the magnitude of active tensile force against time and length are indicated in Fig.1a and 1b, respectively. The installation of the fiber orientation into the finite element model is realized by transforming the standard element in the local coordinate system to the real element in the global coordinate system. As the circulation system model, a simplified electric circuit analogy model is employed in the present numerical simulation. The 3-dimensional geometry of the left ventricle is here assumed to be a prorate spheroid for simplicity. The isoparametric parallelepiped finite elements (198 elements in total) are arranged along the ventricular wall. The mechanical properties of the myocardial fiber and the other various material constants are not determined for a specific individual, but chosen on the basis of studies up to the present as well as the experience and knowledge of medical doctors.

To confirm the reliability of proposed simulation system, the numerical results were compared with the measurements results obtained by the corresponding MR-tagging technique. Fig.2 shows three strain components in myocardium at end systole for normal heart. As recognized from this figure, the simulated results may reproduce well the corresponding results obtained by MR-tagging technique.

3. Numerical results and discussion

The dynamics changes and biomechanical properties are analyzed through a complete cardiac cycle. The reliability of the obtained numerical results is verified through the comparison with the measurement results obtained from the corresponding MR-tagging technique.

In the research work, the analysis of the cardiac functions supposed the following three heart diseases were performed using the proposed simulation system.

(1) HHD (Hypertensive Heart Disease)
(2) DCM (Dilated Cardiomyopathy) accompanied with LBBB (Left Bundle Branch Block)
(3) MI (Myocardial Infarction)

From simulated results (HHD), it is considered that the amount of contraction of the myocardium decreases when the heart becomes the elevated blood pressure condition. It is also considered that the hypertrophy of the myocardial wall in HHD is one of acclimatization developments to compensate a reduction of the stroke volume.

From simulated results (DCM accompanied with LBBB), it is predicted that deformation of the myocardial wall during early systole is affected by the change of electric stimulus transmission pathway due to LBBB, and that during late systole is affected by the decrease of active force due to DCM.

From simulated results (MI), it is assumed that that the blood pressure is kept to some degree when the amount of contraction of the myocardium decreases 50% compared to normal heart.

4. Conclusion

The numerical system to analyze the mechanical properties and functions of the left ventricle has been constructed in this study by combining the mechanical model of the left ventricle with the circulatory

system model. The proposed simulation system can reproduce the generally well-accepted properties and functions of the left ventricle, and also makes it possible to estimate, for example, the stress distributions which are quite difficult to measure, while all of the basic elements of the system are very simple and fundamental. By substituting higher-grade models for the present fundamental models, the more complicated performance of the left ventricle could be reproduced in a more precise and reliable manner. Hence, in the future we can expect objective and quantitative diagnoses for heart diseases by improving the present numerical system.

  There are still many problems to solve before we can realize the ideal simulation system. One of them is that there is a shortage of reliable invivo information about the mechanical properties of the bio-tissues and organ. And even if we could obtain such information, the characteristic complexity, the time dependence and the individual differences of organisms are turned to considerable barriers for the numerical simulation. However, it is expected that numerical simulators like those presented here will pay a major role in overcoming these difficulties.

(a) Relationship between magnitude of active stress and activation time

(b) Relationship between magnitude of maximum active stress and sarcomere length
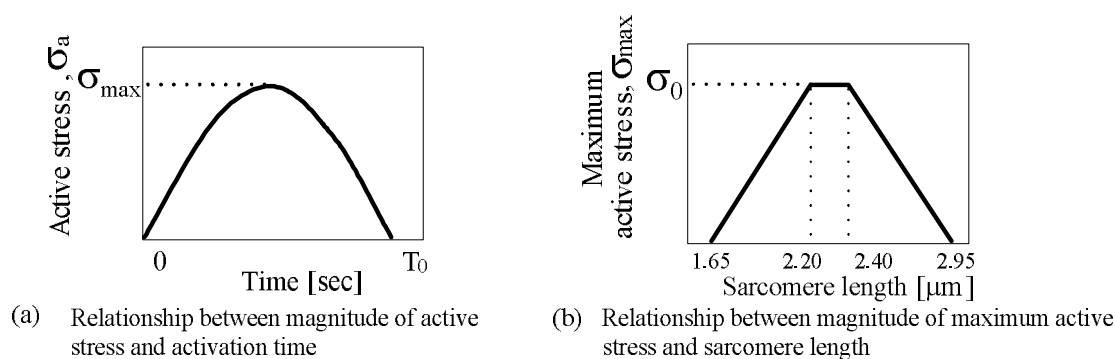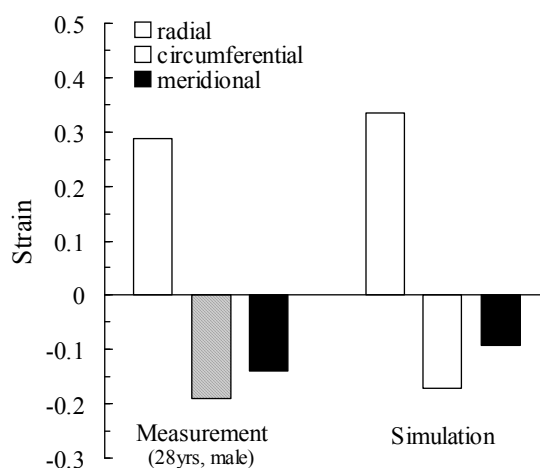
Fig. 1   Mechanical model of myocardium

Fig. 2   Comparison between measurements by MR-tagging and numerical results (FEM) for normal heart

Author's publications

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[2] Masakazu TSUTSUMI, Akiyoshi SHIOMI, Tadashi INABA, Yutaka SAWAKI, Masataka TOKUDA, Finite Element Analysis of Cardiac Function in Hypertensive Heart Disease, Proceedings of 4th World Congress of Biomechanics, Proceedings CD, 2002.
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Experimental Research on Mechanical Properties of
Zr based Bulk Metallic Glass

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1. *Introduction*

Bulk metallic glasses (BMGs) are alloys that have various features that are not observed in conventional metallic materials. BMGs consist of metallic elements with amorphous structures. It has the thickness and size enough to be applied to a structural material, i.e. bulk size, and exhibits the specific glass transition phenomenon different from conventional amorphous alloys. The BMGs show the excellent mechanical properties, high corrosion resistance and exhibit a low magnetic coercive force. In particular, Zirconium-based BMGs have not only high mechanical properties but also high glass forming ability. Due to these remarkable properties, it is expected that Zr-based BMGs will be applied to new structural materials. However, BMGs must be worked and formed at high temperatures into the desired shape for mechanical applications, because it is difficult to plastically deform BMGs at room temperature (RT).

In this study, the influence of thermoplastic deformation on the mechanical properties of BMGs at RT is investigated. In particular, the effects of temperature, strain, and strain rate in thermoplastic deformation on the fracture stress of BMGs at RT is focused on. A comprehension of the dependence of these parameters under hot conditions on the material strength at RT will expedite the industrial use of BMGs.

2. *Experimental method*

The strength properties of $Zr_{55}Al_{10}Cu_{30}Ni_5$ and $Zr_{60}Al_{10}Cu_{25}Ni_5$ BMGs were investigated at RT (293 K). To study the influence of heat alone on the mechanical and atomic structural properties of these BMGs at RT, specimens were heated in a muffle furnace. Subsequently, mechanical loading tests and analysis of atomic structure by using a XRD were performed at RT after cooling. Moreover the plastic deformation behavior of these BMGs at high temperature was studied by using a hot loading machine to which an electrical furnace is attached. The tensile tests were performed at various temperature conditions and strain rates. All the thermoplastic deformation experiments were stopped before the fracture of the specimens. After thermoplastic deformation, the strength properties were studied at RT, and compared with the as-cast materials. To investigate the thermal properties of the $Zr_{55}Al_{10}Cu_{30}Ni_5$ and $Zr_{60}Al_{10}Cu_{25}Ni_5$ BMGs, a DSC was used.

3. *Result and discussion*

The fracture stresses of as-cast $Zr_{55}Al_{10}Cu_{30}Ni_5$ and $Zr_{60}Al_{10}Cu_{25}Ni_5$ BMGs at RT were more than 1500 MPa. These materials exhibited a large elastic strain, extending up to 2.0%. On the other hand, it was difficult to plastically deform these BMGs at RT. The stress-strain curves of these BMGs are similar to those of so-called brittle materials, particularly for the tensile tests. However, several experimental results indicated that the BMGs have mechanical properties similar to those of ductile materials such as steel, although no plastic strain appears in their stress-strain curves at RT.

When the $Zr_{55}Al_{10}Cu_{30}Ni_5$ BMGs were heated at a temperature greater than 685 K in the muffle furnace, this material was crystallized. Furthermore, the fracture stress of crystallized material drastically decreased at RT after cooling. The material undergoing heating above 685 K is embrittled and loses the ductile properties that the as-cast materials possess. However, the $Zr_{55}Al_{10}Cu_{30}Ni_5$ BMG after being heated below 685 K was not crystallized and its mechanical strength can be maintained at levels similar to that of the as-cast samples. On the other hand, the $Zr_{60}Al_{10}Cu_{25}Ni_5$ BMG also maintains the as-cast strength properties after being heated at a temperature below 710 K. Therefore, these temperatures can be considered as the upper limit temperature in order to maintain the as-cast strength after a heating process.

These materials exhibited plastic strain at a high temperature although no plastic deformation appeared at RT. The temperature to allow the plastic deformation lied over not only a higher but also a lower temperature than the upper limit temperature. The property of plastic deformation of these BMGs at a high temperature depended strongly on not only the temperature but also the strain rate.

The three parameters—strain, temperature, and strain rate of the thermoplastic deformation—can be considered to have an effect on the structure of the BMG, and thus on the strength after the deformation, even if the environmental temperature is lower than the upper limit temperature. Therefore, the influence of each parameter on the mechanical properties of the $Zr_{60}Al_{10}Cu_{25}Ni_5$ BMG at RT was studied. The experimental results showed that the strength of this BMG at RT after the thermoplastic deformation depends strongly on the amount of thermoplastic strain, the temperature and the strain rate during deformation. When the strain rate is comparatively low, the strength of this material at RT gradually decreases with increasing the thermoplastic strain. On the other hand, a higher strain rate prevents the strength after thermoplastic deformation from decreasing. Furthermore, the decrease of the strength of this BMG at RT is significant at a higher temperature even if the temperature is lower than the upper limit temperature.

From the thermal analysis by using a DSC, the crystallization temperature of the specimens deformed under various hot conditions changed with the thermoplastic strain. The tendency of the change coincided with those of the strength at RT after the deformation depending on the three parameters. The decrease of crystallization temperature is considered to imply that the material changes into the state to be more easily crystallized because the crystalline phase is precipitated and then a local free volume increases inside the amorphous phase.
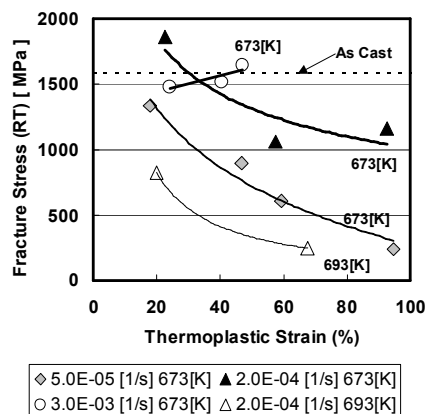

Fig. 1 Influence of thermoplastic strain at 673 K corresponding to strain rate and temperature on fracture stress of $Zr_{60}Al_{10}Cu_{25}Ni_5$ BMG at RT
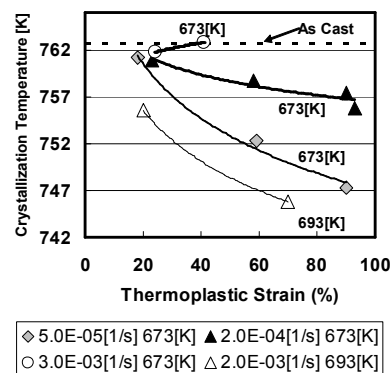

Fig. 2 Influence of thermoplastic deformation parameters on crystallization temperature of $Zr_{60}Al_{10}Cu_{25}Ni_5$ BMG at RT

4. Conclusion

From the experimental results of Zr-based BMGs, the influence of the thermoplastic deformation on the mechanical properties at RT was clarified. It is important and useful from the industrial viewpoint that these BMGs can be freely deformed and the excellent strength properties can be maintained after thermoplastic deformation.

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A Study on the Modification of the Engineering Plastics to the Advanced High-Performance Materials

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Keywords: Engineering plastics, Poly(oxymethylene), Poly(ethylene terephthalate), Poly(ester amide), Ethanolamine, Flame retardancy, Thermal properties, Thermal analysis, Molecular orbital calculation

1. Introduction

Engineering plastics, including Poly(oxymethylene)s (**POMs**) and poly(ethylene terephthalate) (**PET**), have superior physical, mechanical, thermal, electrical and chemical properties, and they have been used in many industrial fields such as the automotive, electrical/electronic, construction and consumer markets. Moreover, in order to apply **POM** and **PET** to various industrial fields as the further advanced materials, the progressive and drastic improvement of the fundamental issues having **POM** and **PET** needs to be performed. As a design methodology for the advanced high-performance engineering plastics, the formulation design by packaging of the optimized functional additives (ex. flame retardants) or the structural modification by introducing of hydrogen-bondable amide groups to the polymer main chain can be expected.

The present paper describes the results of a study on the modification of the engineering plastics to the advanced high-performance materials, including **POM** and **PET**, the objective of which was to produce new advanced plastic compositions and polymers, characterize them, and obtain the fundamental design methodology to create the advanced high-performance materials.

2. Results and Discussion

2.1. A Study on Design Methodology for High-Performance (flame retardancy) of POM [1]

New flame retardant combination system for **POM** was investigated. It was found that **POM** is synergistically flame-retarded by the combination of red phosphorus with novolac as a phenolic resin and melamine as an aminotriazine compound. Furthermore, the detailed combustion behavior of the flame retarded **POM** has been studied to confirm its flame retarding mechanism by using thermal and FTIR analyses. The results of cone calorimetry, thermogravimetry and FTIR analysis suggested that the flame retarding mechanism is the intumescent char formation in the condensed phase. Novolac having a phenolic hydroxyl group is miscible with POM, and in the flaming process, red phosphorus yields phosphine and its acidic product such as phosphoric acid due to hydrolysis and oxidation reactions.

In addition, all of novolac, melamine and phosphine are able to readily react with formaldehyde generating from POM during burning to give the reinforced and cross-linked char network through the polyaddition and polycondensation reactions. Therefore, the red phosphorus/novolac/melamine ternary combination system could synergistically promote the high flame retardancy of POM without the flaming drips.

2.2. A Study on Design Methodology for High-performance of semiaromatic polyesters [2, 3]

Semiaromatic poly(ester amide)s (**PEAs**) were synthesized by the melt polycondensation of ethanolamine (**EA**)-derivatives with dimethyl terephthalate (**DMT**) and ethylene glycol (**EG**) in the presence of tetrabutyl titanate as a catalyst, and their crystallization and thermal properties were investigated.

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Introduction of an amide group into the semiaromatic polyesters such as poly(ethylene terephthalate) (**PET**) gave the **PEAs** (**EA**-modified **PET** polymers) having an increase of melting point.   Interestingly, these **PEAs** were found to decompose at a lower temperature than **PET** on the basis of the TGA analysis. Moreover, the direct pyrolysis/mass spectrometry suggested that an initial step of the thermal decomposition was a β-CH hydrogen transfer reaction via a six-member ring transition state at the ester-ethylene-amide unit, at which the carbon-oxygen bond scission takes place to yield carboxyl and *N*-vinylamide end groups (Scheme 1).   Furthermore, molecular orbital calculations using trimer model molecules supported strongly that the β-CH hydrogen transfer reaction in the thermal decomposition of **PEAs** occur more easily at the methylene group next to the amide group in an ester-ethylene-amide unit rather than at the methylene group next to the ester group in an ester-ethylene-ester one (Figure 1).
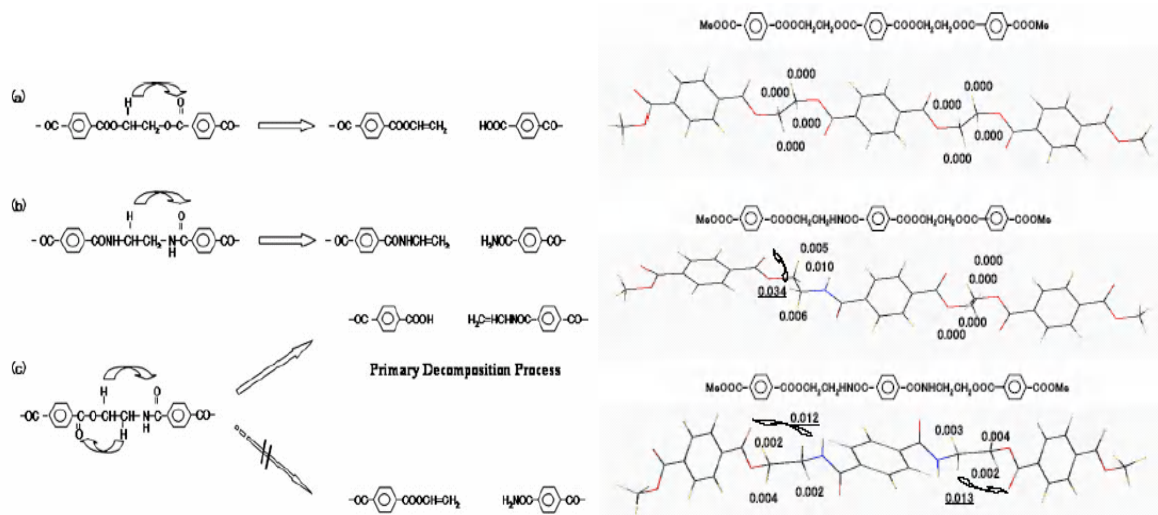
Scheme 1.	Figure 1.
The β-CH hydrogen-transfer reactions of (a) **PET**, (b) poly(ethylene terephthalamide), and (c) **PEAs**.	Frontier electron densities on ethylene protons for trimer models of **PET** and **PEAs**.

3. Conclusions

i) The red phosphorus/novolac/melamine ternary combination system could promote the high flame retardancy of **POM** without the flaming drips.   The flame retarding mechanism was the intumescent char formation to give the reinforced and cross-linked char network through the polyaddition and polycondensation reaction in the condensed phase.

ii) Semiaromatic poly(ester amide)s (**PEAs**) were synthesized by the melt polycondensation of ethanolamine derivatives with **DMT** and **EG**. The primary thermal decomposition of **PEAs** was a β-CH hydrogen transfer reaction via six-member ring transition state in the ester-ethylene-amide unit to form carboxyl and *N*-vinylamide end groups. The thermal decomposition behavior of **PEAs** was explained well by semiempirical molecular orbital calculations on the basis of timer model molecules.

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A Study of the Reception Space Planning of Homes for the Elderly

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1. The significance of setting reception space of a nursing home as a research theme

The act of receiving guests in a homelike environment has been considered to be an important act that ties people inside the house and those outside, and various types of reception space have been created in the private homes. However, in spite of its importance, the reception space of nursing homes has never been discussed in detail, nor even the actual situation is grasped yet. Current national policy for the preparation of the nursing homes is to attain the continual homelike environment before and after entering them. Thus, more and more attention is to be paid to the reception space. In this sense, it is necessary to grasp the current conditions of the reception space of the nursing homes and to propose a guideline to them.

2. 2 Purpose of the Study

A study of the reception space planning is a new perspective. Therefore, there are almost no previous studies of this matter. This study aims to set up some guidelines for the nursing homes to become a place where both the residents and the visitors feel at home. This is done by (1) overviewing the current trends in order to extract their characteristics, and (2) analyzing the reception space in detail.

3. Definition of the reception at a nursing home

It is defined as residents and visitors "sharing time comfortably."

4. Status of visitors

There are two types of visitors to nursing homes: one is those who come to see the residents individually; the other is those administrating the programs of the nursing homes.

5. The institutions investigated

In order to grasp the current situation of various types of homes for the elderly, the institutions investigated are those covered by the public nursing care insurance set by the Ministry of Health, Labor and Welfare. The author sent out a questionnaire to a total of 55 institutions: 19 special nursing homes, 9 group homes, 10 care houses, 2 private nursing homes, 13 geriatric health care institutions, 2 geriatric medical care hospitals. In addition, the author visited 11 institutions: 4 special nursing homes, 3 geriatric health care institutions, 1 geriatric medical care hospital, 1 group home, 2 care houses.

6. The method of this study and its results

This study is carried out in five phases through "interviews and questionnaires to people involved in the act of reception" and "the observations of the receptions space of the institutions."

[Issues of the Reception at the Homes for the Elderly]

Processes and problems involving the act of reception (chapter 2) aim to grasp the actual situation of the reception at the institutions, to organize the significance of reception and the problems of reception at institutions, and to propose the topics to be discussed in the following chapters. What is clarified here is that the act of reception is necessary for residents of the institutions since it facilitates psychologically affirmative effects and that the institutional programs are necessary especially at the institutions for the aged since it leads to heartwarming mingling at various places in the site of the institutions. Following matters are to be considered for individual visits: frequencies of the visits, location of the institutions, equipment of the rooms, reception at the common space, and the awareness of the people involved in the act of reception. As to the institutional programs, environments that generate conversations and the awareness of the people involved in the act of reception are to be considered.

As to the changes of reception after moving into institutions (chapter 5), some specific characteristics of the life in the

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institutions are extracted in contrast to those found in the private homes. What is clarified to be of importance as to the location of the institutions is the accessibility by private cars. This is because many of the visitors visit the institutions by car regardless of the distance from their residence. Next, reception at the common space and the attitudes of the inmates and the guests are investigated. The act of reception is found to be performed not only in the private rooms but also at various places inside and outside the institutions. The private rooms are preferred because in there both the guests and the inmates are able to enjoy private conversations in an intimate atmosphere. On the other hand, the guests have to care a lot about the health condition of the inmates and the inmates are sometimes reluctant to show their private space to the guests. That is why they go outside the private rooms for a walk or for a change of mood. In order for the inmates to enjoy the reception outside the private rooms "without feeling any constraints," following places are preferred: half-private living rooms, dining rooms, corridors, entrance halls, meeting rooms, bathrooms and outside institutions. Of course, different institutions have different facilities (i.e., presence or absence of certain equipment) and these also affect the details and frequencies of the act of reception.

[Extraction of the Conditions of the Reception Space Planning]

As to the equipment of the reception space of the institutional program (chapter 3), observation and analysis are done in order to grasp the conditions in which the act of reception through the program prepared by each institution becomes successful by the visitors who take part in the program and to clarify the condition for the preparation of the reception space. As a result, six types of institutional programs (i.e., viewing-type, circle-type, service-type, luncheon-type, conversation-type, and festival-type) are proved to be used differently in the care space, in the common space outside the care units in the building, and outside the building. Also, necessary conditions for each space division are clarified.

As to the case study of how the change of the reception space affects the atmosphere of the reception space (chapter 4), in order to clarify the factors that may improve the quality of life (QOL), observation and analysis from the point of view of the relationship between the improvement of the living conditions and the reception circumstances are done through the cases of reconstruction of the hospitals for long-stay inpatients. As a result, necessary conditions for the preparation of the space in the private rooms, necessity of the places for the visitors to have a rest and exchange information and their requirements are extracted.

As to the equipment of the reception space of the institutions (chapter 6), in order to clarify the factors that bring about the reception, observation and analysis of the equipment are done by comparing the equipment of the places where reception is done. As a result, conditions for the staff members' ease of assistance and environmental conditions of private rooms, dining rooms, living rooms, and the space for residents and visitors to move together are clarified.

Lastly, a reception space planning checklist is proposed by summing up the results obtained by analyzing the situation and factors of reception, the conditions necessary for the preparation of the reception space, and the program conditions necessary for the preparation of the reception space. Furthermore, the checklist is applied to the two institutions (new KT hospital for long-stay inmates, and Y special nursing home) of which the author involved in designing and the designing concept is "the actualization of the homelike atmosphere." The problems of the design concept are in conformity with the ones drawn from the reception space planning checklist. This demonstrates that the reception space planning checklist obtained as a result of this study is effective in the actual design of the construction.

The reception space planning checklist proposed in this study is useful not only in designing an institution that aims to fulfill homelike atmosphere but also in administrating an institution since it gives us beneficial information on the improvement of the residents' facial expressions and physical conditions. The author, therefore, expects it to be widely accepted.

Although this study focuses on the reception space planning for the institutions of the elderly, its concept is applicable to the institutions where the mentally and/or physically malfunctioning people live or receive medical care as well as to the institutions for the elderly who require nursing care since the act of reception is an indispensable activity for a human to live.

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A quantitative study on the camera calibration error

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(Machine vision，Division of system engineering)

1.Purpose

The object's position on the image taken by the camera gives the information on the direction of a visual line cast by the camera on the object. Like a triangular surveying where the number of observing points is two, by using the information on the direction of a visual line from two or more observing points, 3-D position for the target can be presumed by fusing these. In order to perform this with high accuracy, we require the directions of visual lines with sufficient accuracy. Here, cameras involve some important camera parameters such as the principal point that is the intersection of the optical axis of camera with the image plane, the principal distance that is the distance between the center of lens and the image plane, and the length of 1-pixel on the image plane. So, these parameters are used for transforming image coordinates into visual lines with respect to the camera, not only measuring the image coordinates of object's feature points, but also we have to calibrate the camera parameters. So, camera parameter calibration is the basic and practical technique in the field of 3-D measurement based on visual information. So, in this research, we focus on the 2-plane calibration method is one of the simplest calibration methods, in the field of calibration technique, that use the reference such as the points and lines whose configuration are known, and conduct a study of following 3 perspectives.

  1. Raising the precision of camera parameter calibration
  2. Quantification of the calibration error to the true value of camera parameter
  3. Evaluation of 3-D estimation error due to the calibration error

The outline of each viewpoint is as follows.

1. The accuracy of 2-plane calibration method calibrates the camera parameters by taking a picture of the calibration fiducial chart moving in the depth direction is affected by following factors.

・Amount of movement in depth direction of the calibration fiducial chart

・Imaging condition while photographing the calibration fiducial chart

So, we propose a new imaging condition from the perspective improving the accuracy of calibration, and optimize the amount of movement in the depth direction of the calibration fiducial chart.

2. New imaging condition and traditional imaging condition, in addition, we suppose the imaging condition that is possible in practical use, and formulized the accuracy of camera parameter calibration into the amount of movement in depth direction of the calibration fiducial chart.

3. So, the essential information obtained from 2-D image is visual angle that is the angle in which observing the object from camera, and is 3-D information, it is important to evaluate the accuracy of camera parameter calibration by using visual angle. In this research, we suppose the method to evaluate the error of visual angle accurately, and ascertain the characteristics between camera parameter calibration error and visual angle.

1. The candidate in this research

As before, in this research, we focus on the 2-plane calibration method. And, the parameters to be calibrated are following camera parameters.

  ・Principal point : the intersection of the optical axis of camera with the image plane
  ・Principal distance : the distance between the center of lens and the image plane
  ・The length of 1-pixel on the image plane

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And, we are premised on pinhole model as camera model. In addition, the 2-plane calibration method is the calibration method calibrating the camera parameters by taking a picture of the calibration fiducial chart moving in the depth direction.

2. Calculational procedure

In this research, We assume that the error is caused from the observation error of image coordinates of the fiducial points arisen in which we observe the fiducial points arranged on the calibration fiducial chart. Therefore, we calculate the error from camera to object calculated based on value of camera parameter calibration by using law of error propagation.

3. The influence of the imaging condition on the accuracy of calibration

The accuracy of 2-plane calibration method is affected by the imaging conditon in which we take a photo of the calibration fiducial chart. So, we optimize the distance of the calibration fiducial chart, and formulize the calibation error of principal distance under the condition that the number of fiducial points are photed at the position of the calibration fiducial chart is near and far from camera is same (imaging condition.1). In addition, we formulize the calibration error of principal distance and the length of 1-pixel on the image plane under the condition that the additional fiducial points are photed at the position of the calibration fiducial chart is far position(imaging condition.2). By taking a photo of more fiducial points, we can advance the accuracy of calibration in 2-plane calibration method.

4. The influence of the setting error of the calibration fiducial chart on the accuracy of calibration

In actual use, there is a possibility that the position and the angle of the calibration fiducial chart. So, we formulize the accuracy of calibration if the position and the angle of the calibration fiducial chart involve errors.

5. The evaluation of the camera parameter calibration error by using visual angle

The essential information obtained from 2-D image is visual angle that is 3-D information and is the angle in which observing the object from camera. So, it is important to evaluate the accuracy of camera parameter calibration by using visual angle. In this research, we suppose the method to evaluate the error of visual angle accurately, and ascertain the characteristics between camera parameter calibration error and visual angle. And finally, we formulize the error of visual angle.

6. Conclusion

In this research, we focused on the 2-plane calibration method is one of the simplest calibration methods in the field of calibration technique. And, we examined the accuracy of calibration under the imaging condition.1 and imaging condition.2. Then, we optimized the amount of movement in depth direction of the calibration fiducial chart, and ascertained accuracy of calibration is improved under the imaging condition.2, and formulized the calibration error of camera parameters under each imaging condition. In addition, in practical use, there is a possibility that the position and the angle of the calibration fiducial chart, so that we formulize the accuracy of calibration if the position and the angle of the calibration fiducial chart involve errors. And finally, so the essential information obtained from 2-D image is visual angle that is 3-D information and is the angle in which observing the object from camera, we ascertained the characteristics between camera parameter calibration error and visual angle, and formulize the error of visual angle.

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Study on Systematization of Porous Concrete with Small to Large Size Aggregates

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1. INTRODUCTION

Porous concrete is environmentally friendly material that has continuous voids inside to be used widely in various fields. The performance of porous concrete is largely determined by the size and quantity of the internal pores, and pore size is controlled and adjusted by the aggregate grain diameter used as well as the volume of bonding material. However, according to the past papers, most of studies on the porous concrete，the aggregate of the particle size 2 - 20 mm has been used. Therefore, in this study, to expand the usage of porous concrete, manufacturing method and fundamental properties of porous concrete with small to large size aggregates have been examined. With small size aggregate（particle size: 0.6 - 2.5 mm）, it was defined as small particle size porous concrete, while with large one（particle size: 40 - 400 mm）, it was defined as large particle size porous concrete. **Table 1** shows the placement of this study in porous concrete. In addition, to analyze the theory of compressive strength of porous concrete, a geometric model with ideally spherical aggregates was proposed.

2. EXPERIMENTAL STUDY ON FUNDAMENTAL PROPERTIES OF SMALL PARTICLE SIZE POROUS CONCRETE

Basic properties of small particle size porous concrete（hereafter referred to as "SPOC"）were examined. According to the test results, SPOC was superior in water retention and pumping compared to normal particle size porous concrete（particle size: 5 - 13 mm）. **Fig. 1** shows that the smaller the aggregate grain, the higher the water retention and pumping rate. It should be noted, however, that permeability of SPOC is rather low.

3. EXPERIMENT AND MODELING ON RELATIONSHIP BETWEEN COMPRESSIVE STRENGTH AND VOID RATIO OF POROUS CONCRETE

There was little theoretical examination on the relationship between void ratio and compressive strength

Table 1　The placement of this study in porous concrete

Classification		The object of this research		Area investigated in the past				The object of this research
		Small particle size porous concrete (Porous mortar)		Porous concrete				Large particle size porous concrete
Aggregate	Particle size	0.6～1.2mm	1.2～2.5mm	2.5～5mm	5～13mm	13～20mm	20～40mm	40～400mm
	Kinds of material	Crushed fine stone, Molten fine slag		Crushed stone, Recycle aggregate				Crushed stone, Concrete rubble
Construction method		Mixing by mixer ⬇ Tamping vibration / Spraying		Mixing by mixer ⬇ Tamping vibration				Integration of coarse aggregate by spraying binder
Application field		Water retentive and pumping pavement						
		Water penetration pavement						
		Base for greenery		(Grasses)				(Trees)
								(Fishing reef)

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of porous concrete. Therefore, a simple geometrical model concerning compressive strength was proposed, and the calculated values were compared with the experimental ones. From the result, it is possible to predict the experimental results by means of the proposed model. Especially, in the case of direction 1, orthorhombic lattice array showed an excellent presumption accuracy（**Fig. 2**）.

4. FUNDAMENTAL STUDY ON MANUFACTURING METHOD OF LARGE PARTICLE SIZE POROUS CONCRETE

Manufacturing method of large particle size porous concrete（hereafter, referred to as "LPOC"）using concrete rubble was examined. As the aggregate grain diameter was large, it was difficult to mix LPOC by means of a normal mixer. Therefore, in stead of manufacturing with a mixer, a binder was splayed on the upper surface of the concrete rubbles of every layer. By the experiment, it was confirmed that LPOC was producible by the spraying method.

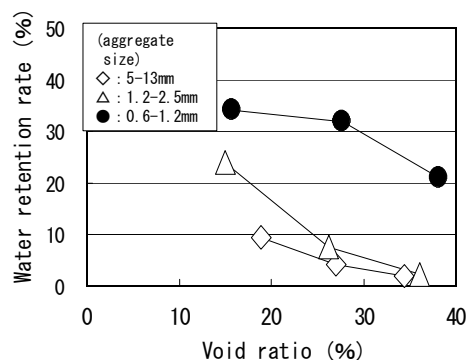## 5. APPLICABILITY AS FISHING REEF OF LARGE PARTICLE SIZE POROUS CONCRETE

Experiments have been carried out to confirm applicability of LPOC as the fishing reef. Firstly, to confirm stability of fishing reef placed in a sea, LPOC was sunk in the large-scale waterway where waves and currents can be generated. It has been found that void of fishing reef decreases the power of current and wave, and the effect on wave is especially large. Next, to confirm applicability as a fishing reef for marine creatures, 70 LPOC blocks（size: 1 m × 1 m × 0.7 m）were sunk into Ise bay of Mie Prefecture. After six months, lobsters, abalones, sea cucumbers etc. were found to live in LPOC. Judging from the result, LPOC is useful to fishing reeves.
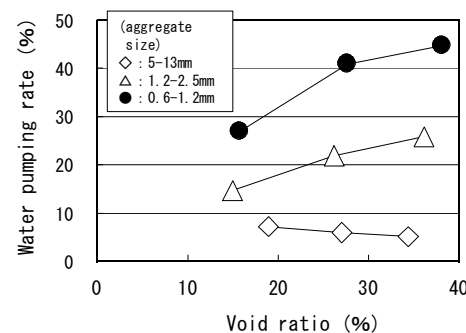
6. CONCLUSIONS

In the present study, a new performance of porous concrete was recognized. Moreover, a geometrical model concerning compressive strength of porous concrete was proposed. In the future, it is expected that results of this study contribute to the development for porous concrete.

（a）Water retention rate

（b）Water pumping rate

Fig. 1 One example of test results of small particle size porous concrete
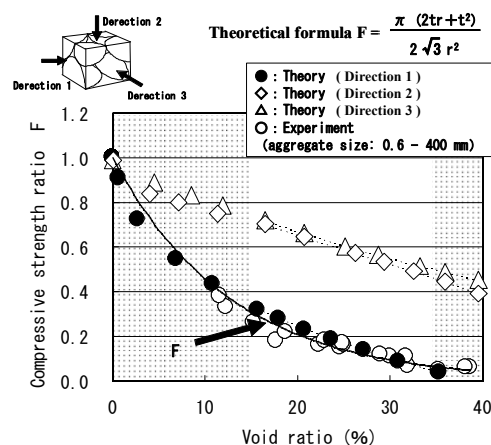
Fig. 2 Comparison between theoretical value and experimental value
（In the case of orthorhombic lattice array）

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Flow Analysis of Particle Laden Two-Phase Jet Flow from Rectangular Nozzle and Its Application to Micro-Blasting Process

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Keywords: Rectangular jet flow, Gas-solid two phase flow, Micro-blasting

1. Introduction

Micro-blasting process, MBP by particle laden impinging air jet flow with the order of 10mm particles has been increasing in order to process brittle materials, such as glass or ceramic, as the fine process for high accuracy and productivity. In MBP, a circular nozzle is used commonly, yet it takes a large number of scanning times to process a wide area, and then a long machining time. Recently, use of a two-dimensional rectangular nozzle has been considered to process a large area with high efficiency. However, it is difficult to obtain uniform and high accuracy for cutting depth over the nozzle width.

In this study, in order to improve the cutting performance of an MBP nozzle, a new rectangular nozzle with a large aspect ratio is proposed and the flow characteristics and cutting performance are examined precisely.

2. Experimental and results

Figure 1 shows the nozzles used. The first nozzle is considered in order to change a circular cross section to a rectangular one. The second nozzle has three bars in it to diffuse or spread the flow. The third and forth nozzles are proposed to improve the cutting performance. Particle laden impinging jet is used to process the brittle material, glass plate. Particle used is silicon carbide, SiC of 50% diameter d_{p50} is 25μm.

The particle behavior from each rectangular nozzle was measured by PIV. The cutting performance of nozzle was examined by evaluating the shape of cutting cross section of grass plate. The cutting efficiency was evaluated by comparison of cutting removals per supplied power with conventional circular nozzle.

Figure 2 shows the visualized flow pattern in the half right had the particle velocity vectors and in the half left had the particle concentration for the free jet of each nozzle, respectively. In the case of 1st nozzle, particle does not disperse to y direction, it concentrated at center of nozzle, y/h=0. However setting the vane in nozzle, particle dispersed to y direction, 2nd nozzle shows uniform concentration except edge of nozzle. The concentration of 3rd nozzle has uniform all over the nozzle width, then the velocity vector becomes uniform, too.

The cutting performance of each nozzle is shown in Fig.3. All of the case, cutting depth correspond with particle concentration, dense region becomes deep and thin region becomes shallow. Center of nozzle and near the both side edge in y direction the cutting depths of 1st and 2nd nozzle are considerably. On the other hand, the 3rd nozzle has a high cutting performance, the accuracy of cutting depth of it is within 10% in the wide range at $-70<y/h<70$ since particle flow is uniform.

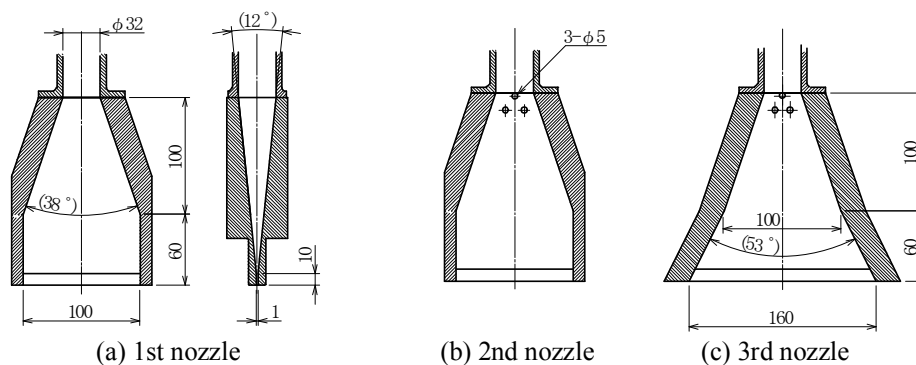Figure 4 shows the cutting efficiency of 3rd nozzle with conventional nozzle. The 3rd nozzle has the largest

(a) 1st nozzle   (b) 2nd nozzle   (c) 3rd nozzle

Fig. 1   Details of new rectangular nozzle

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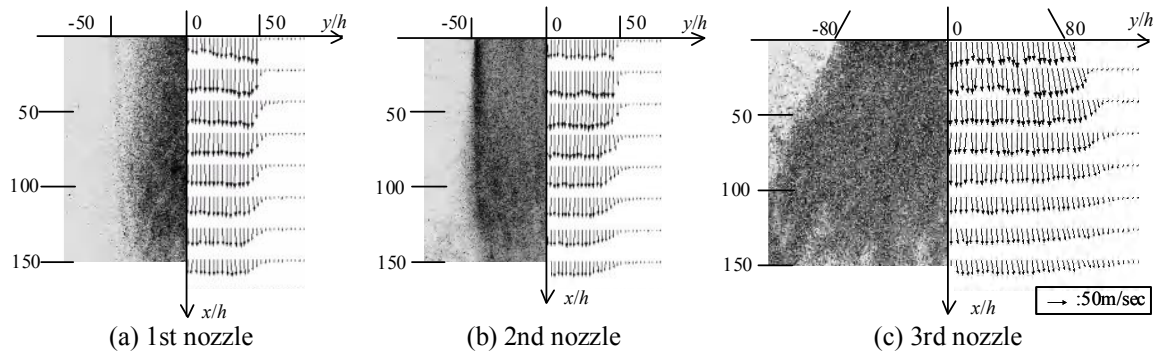(a) 1st nozzle   (b) 2nd nozzle   (c) 3rd nozzle

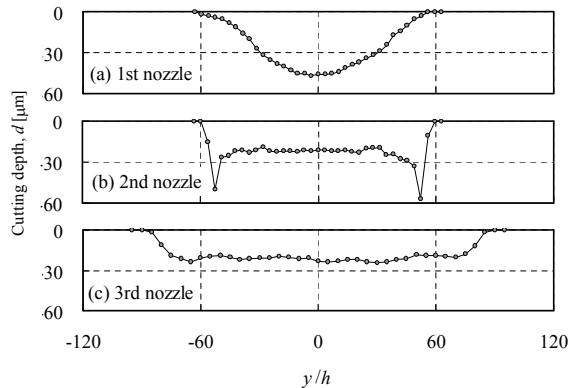Figure 2   Particle flow image and particle velocity vector

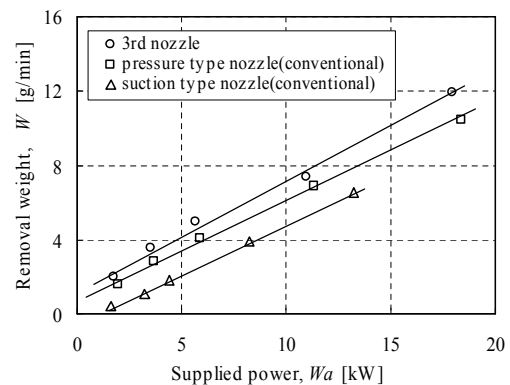Figure 3   Cutting profile of work-piece   Figure 4   Cutting efficiency

cutting efficiency under the same supplied power. The cutting rate of the 3rd nozzle is almost 1.2 times of the conventional circular nozzle, and moreover it has a larger processing speed. It results from reduction of particle-particle interaction and improvement of particle discharging from impinging spot at work-piece.

3. Conclusion

Main results are as follows,

(1) The circular vane is effective to uniform the particle flow. Also, uniform particle flow can be obtained by expanding the nozzle exit.

(2) The cutting accuracy shows a high quality of within 10% at $-70 < y/h < 70$ for the 3rd nozzle.

(3) The 3rd nozzle takes the largest removal weight compared to the conventional circular nozzles. For example, cutting efficiency of the 3rd nozzle improves by 20% of the pressure type nozzle at the supplied power of $W = 10$kW.

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Investigations on a Vertical Upward Gas-Liquid Two-Phase Flow through Sudden Contraction or Expansion Pipe

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Keywords: Bubbly two-phase flow, Sudden expansion-contraction pipe, Fluctuating flow, Flow control

1. The purpose

The aim of this research is to study the pipe flow characteristics when a gas-liquid two-phase flow passes through a vertical abrupt contraction or expansion area. The effect of several parameters, such as Reynolds number and volumetric gas flow rate, are considered. Drag and fluctuating phenomena are investigated and simple plus economic flow control methods are proposed and their results are presented.

2. Related prior arts

Two-phase gas-liquid flow systems are frequently seen in the industrial field. Several studies have been conducted so far, such as Aloui et al. (1999), conducting experiments for the singularity pressure drop, void fraction, wall shear stress, bubble velocity and size, or Kondo et al. (2003) giving valuable information concerning flow regime difference, local void fraction flow observation on bubble deformation.

However, studies dealing with the fluctuating phenomena and drag of the expansion /contraction area, and methods of flow control are scarcely seen in the bibliography.

Fig.1 FFT analysis results
($A =0.18$, $Re=2 \times 10^4$, α_v=5%)

3. Results and discussion

3.1 Sudden contraction pipe flow

The present work is divided into two main parts. Part one, is the case of a sudden contraction and part two, the expansion case. In both cases flow parameters were varied and the effect on the flow pattern was investigated.

For the case of a sudden contraction, prior to and after the contraction area, vortices generate, affecting significantly the downstream flow. The flowing conditions affect the size and length of it and fluctuating phenomena were observed. When the flow control method was applied, it showed a remarkable suppression of the vortex generation downstream, which is closely related to drag and fluctuation phenomena. In the following, fig.1 shows the comparative results from FFT analysis conducted between the plain contraction and when a ring shaped obstacle (proposed method) is attached in two different upstream positions. It is clear that the PSD value, which represents the intensity of the fluctuation, is largely suppressed when the flow control method is applied. This verifies that flow control is been achieved.

Fig.2 Drag reduction rate, L_r/H=1
(Re=1$\times 10^4$)

Figure 2 shows the results from the drag reduction measurements. Pressure distribution along the vertical axis was measured and the pressure loss difference due to the contraction effect was investigated.

3.2 Sudden expansion pipe flow

After the positive results from the proposed flow control method, investigations on the sudden expansion case were conducted. Similar to the contraction, on the downstream, vortex area is generated. In addition, due to the buoyancy force of the bubbles a gas-free region exists just downstream the expanded area. The area of this region is strongly affected by the liquid velocity. In addition, even though an axisymmetric sudden expansion,
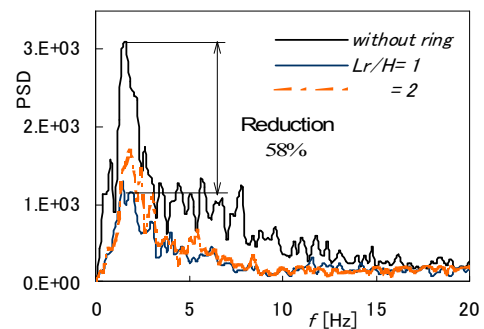
small changes in the force balance within the vortex region cause instabilities and fluctuating phenomena occur.

Two flow control methods were investigated. One, mounting the ring shaped obstacle at several downstream positions, dividing the vortex region into two parts and reducing its intensity. The second, installing a step-ring just after the expansion in order to reduce the recirculation area size.

It was found that two dominant frequency peaks exist. In addition, the second peak is strongly affected by the gas fraction as shown in fig.3. Increasing the volumetric gas fraction, it shows a tendency to shift its frequency to lower values even under different Reynolds number.

In fig.4, the FFT result between the plain expansion and the two suggested methods is illustrated. The fluctuation amplitude is considerably suppressed for both dominant peaks.

The drag reduction occurring due to the flow control method was also calculated and results are presented in fig.5. Reduction under all flow conditions was achieved, with values reaching up to 40% at its maximum.

Fig.3 Second peak frequency variation under various Re number and gas fraction

Fig.4 FFT analysis results ($Re=1\times10^4$, $\alpha_v=5\%$)

4. Concluding remarks

1) From visualization results in both cases it was made apparent that the vortex region is strongly affected by the Reynolds number and volumetric gas fraction.

2) Fluctuation phenomena were investigated downstream the contraction/expansion. The dominant fluctuation frequency is affected significantly by gas fraction. Two dominant peaks were observed up to $\alpha_v=20\%$ for the sudden expansion, while just one was seen for higher values showing a tendency to shift its frequency to lower values in all cases.

3) When a ring is mounted, the frequency value did not change. This denotes that the geometric structure does not affect it. The most effective ring position shifts downstream for all Re number when increasing α_v.

4) Applying the flow control method, manages to suppress the vortex generation and reduces the fluctuation intensity, reaching values up to 70% depending on the flow conditions

5) The losses occurring due to sudden changes were investigated and by the proposed methods, drag reduction was achieved. Positive results could be retrieved at all conditions with values reaching up to 40%.

Fig.5 Drag reduction rate, D_R, ($Re=2\times10^4$)

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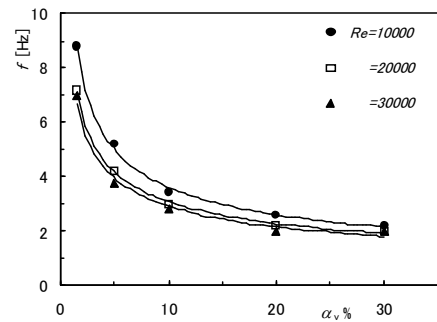
A study of efficient downlink packet transmissions technique for CDMA cellular mobile communications

Abubaker Faraj Khumsi †

1. The purpose

The aim of this study is to improve the system capacity in CDMA cellular systems, especially in downlink communications. The focus on the applications which do not have stringent delay requirements such as web browsing and file transfer, the real time transmissions are not always necessary and time delay is tolerable such as IP packets. Since the CDMA cellular system is the major system and succeeded in the commercial application, the focus in this thesis is on this technique.

2. The related prior arts

The rapid growth in demand for mobile communications has led into intense research and development effort towards a new generation of cellular systems. The new system must be able to provide quality of service (QoS), support a wide range of services and improve the system capacity. In the cellular systems, the mobility causes dynamic variations in link quality and interference levels, sometimes requiring that a particular user change its serving base stations. This change is known as a handoff. Usually, continuous service is achieved by supporting handoff from one cell to another. The availability of cheap and reliable wireless Internet access will shift the service base traditionally found in mobile cellular networks toward emerging wireless Internet service. This will result in significant demand being placed on both existing and next generation cellular and IP networks. The key challenge in realizing an IP wireless network is how to support soft handoff in order to minimize the packet losses and enhance the system performance. Although the soft handoff is an effective way to increase channel capacity, reliability, and coverage of CDMA (Code Division Multiple Access) systems, it has some disadvantages especially in downlink channels. One of the main problems is that the simultaneous multiple base station transmissions will cause an increase in the interference that affects other radio links, and consequently limits the downlink capacity. The conventional scheme, Site Selection Diversity Transmission Power Control (SSDT), which realizes site selection transmission diversity instead of the full site transmission diversity during soft handoff mode has also some shortcomings. The disadvantage of this scheme is that in bad channel conditions the larger transmitted power is required to compensate the fading. As a result of this, the downlink interference increases.

3. Proposed methods abstract

This thesis focuses on the applications which do not have stringent delay requirements such as web browsing and file transfer, the real time transmissions are not always necessary and time delay is tolerable. The aim of this thesis is to enhance the system performance for the downlink IP packet transmission by improving the transmission delay and geographical unfairness in transmission quality.

This thesis divided into three parts; in the first part we propose a transmission control scheme to support IP packets transmission on CDMA wireless networks. The objective of this proposal is to improve the system capacity with maintaining the minimum service disruption during handoffs of the mobile stations. In this proposed scheme, if the channel condition is bad due to fading fluctuation, the base station delays the packet transmission until better channel conditions are available. In other words, the base station sends the packets only when the instantaneous attenuation from the transmitting base station is less than a threshold value. The performance assessment of the simulation results proved that by applying this proposed scheme the system throughput would be efficiently improved.

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In the second part of this thesis; the location-based transmission power and window control scheme (location-based TPWC scheme) is proposed. The objective is to improve the transmission delay performance and the geographical unfairness in transmission quality. In the conventional TPWC and multi-link packet transmission (MLPT) scheme, the packets are sent only during a transmit time window according to the propagation conditions. Besides, MLPT scheme reduces the delay caused by TPWC. However, by applying this conventional scheme, there will be a considerable increase in the transmission delay under some circumstances owing to the delay packet transmission. To avoid these shortcomings, the proposed scheme offers the same transmission window size for all mobile stations in order to improve the delay and unfairness. By using the soft handoff status as an indicator of the mobile locations, the base station individually adjust the transmission window for each mobile station. By maintaining almost the same size of transmission window for all the mobile stations, which is attained by adjusting the required threshold value for each mobile station, the transmission delay performance and the geographical unfairness can be improved.

In the third part of this thesis; an adaptive transmission window control scheme based on soft handoff status and traffic load is proposed. This scheme is proposed to avoid the shortcomings of our previous proposed scheme (a location-based TPWC scheme). The location-based TPWC scheme improved the delay performance and geographical unfairness, but the selected threshold values which constrain the transmission window are not optimum for all traffic loads. In this proposed scheme the threshold values are controlled by taking into account not only the locations of the mobile stations but also the traffic load. The advantage of this scheme is that the optimum threshold values are chosen for each traffic load. The throughput and transmission delay performances for the proposed scheme were evaluated by computer simulations. Based on the simulation results, the proposed scheme can achieve the same throughput performance and improve the delay performance compared with the conventional schemes. Furthermore, the performance comparison concludes that the proposed scheme is better than the conventional ones for maintaining fairness of service to all mobile stations at different traffic loads. Accordingly, the proposed scheme is effective for packet transmissions in CDMA cellular packet communication systems.

4. Concluding remarks

This thesis investigated the packet transmission control in downlink CDMA cellular systems. Several techniques are proposed to cope with the recent trend in wireless communications. This trend is to provide the mobile users with ubiquitous access to the Internet, mobility and handoff. Mobility management is an important issue in the area of mobile communications. These proposed schemes reduced the service disruption during soft handoff phase and improved the system capacity. The techniques proposed in this thesis contribute to the development of the future mobile systems.

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Study on Mitigation Methods of Non-Linear Distortion for OFDM Based Wireless Communications Systems

Pisit Boonsrimuang †

Keywords: OFDM, PAPR, Non-Linear channel, Inter-modulation noise, WLAN channel, Satellite channel Clipping, DAR, IDAR and Dummy sub-carrier insertion.

1. The purpose

The purpose of this research achieves the high transmission data rate in the non-linear channel for Orthogonal Frequency Division Multiplexing (OFDM) based wireless communications systems. The targets of research are to achieve the best bit error rate (BER) performance with efficient usage of non-linear power amplifier at the transmitter. In this research proposes the several solutions of non-linear distortion, which could provide various practical solutions for next generation of multimedia wireless communications systems employing the OFDM technique.

2. The related prior arts

One of the limitations of using OFDM technique is the larger Peak to Averaged Power Ratio (PAPR) of its time domain signal. The larger PAPR signal would cause the severe degradation of BER performance and the undesirable frequency spectrum re-growth both due to the non-linear distortion occurring in the non-linear amplifier which is usually required at the transmitter in the wireless communications systems. The simple solution to overcome this problem is to operate the non-linear amplifier at the linear region with taking the enough larger input back-off (IBO). However, this approach leads the inefficient usage of non-linear power amplifier, and would lead a serious problem on battery consumption especially for the cases of mobile terminal and portable wireless LAN terminal. In order to maximize the usage of power efficiency, the non-linear amplifier is usually forced to operate at the near its saturation region. However this approach will lead to the severe degradation of BER performance and undesirable frequency spectrum re-growth for the larger PAPR signal due to the occurring of inevitably higher non-linear distortion.

3. Proposed methods abstract

The PAPR problem is currently recognized as one of the essential research topics when employing OFDM technique in the non-linear channel. Up to today, various kinds of methods were proposed in order to solve the PAPR problem. These proposed methods could be mainly categorized into two types of methods; 1) to reduce the PAPR to extend possible at the transmission side, and 2) to compensate the non-linear distortion at the receiver side.

As for the first type of methods, there are three major proposals which can improve the PAPR performance at the transmission side, that are the selected mapping method (SLM), partial transmit sequence method (PTS) and dummy sequence insertion method (DSI). All of these methods can provide the better PAPR performance by controlling the phase of data or dummy sub-carriers. The SLM and PTS methods control the phase of data sub-carrier and the DSI method controls the phase of dummy sub-carriers at the transmission side. First two methods are required to inform the phase information controlled for the data sub-carriers to the receiver as the side information. On the other hand, the DSI method requests no side information, because of using dummy sub-carriers, which could be discarded at the receiver. From this reason, the DSI method could be realized with almost the same system efficiency and less overall system complexity as compared with the PTS and SLM methods. Although the PAPR performance could be improved as increasing the number of predetermined discrete phases, the computation complexity would increase due to the necessity of larger number of iterations in the flipping algorithm.

From this fact, the conventional DSI method has a limitation on PAPR improvement when assuming the small number of predetermined discrete phases so as to keep the acceptable computational complexity.

To solve the above problem on the conventional DSI method, this research proposes two novel PAPR reduction methods both of which can achieve the better PAPR performance with less computation complexity than the conventional DSI method. The feature of the first proposed DSI method is to employ the time-frequency domain swapping algorithm in the determination of frequency data for dummy sub-carriers. In the proposed method, the larger amplitude levels are detected in the time domain and these amplitude levels are converted to the frequency domain to determine the frequency data for the dummy sub-carriers. These procedures are repeated up to reaching either of the predetermined PAPR performance or the number of

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predetermined iterations. The feature of second proposed method is to enable the determination of frequency data for each dummy sub-carrier theoretically by using the continuous phase. From this fact, the proposed method can achieve the better PAPR performance with less computation complexity than that for the conventional DSI method. From the computer simulation results, it is confirmed that these two proposed method can achieve much better PAPR performance and BER performance than the conventional method with less computation complexity in the non-linear channel.

As for the second type of methods, the clipping method in conjunction with the Decision Aided Reconstruction (DAR) method was proposed to compensate the clipping noise at the receiver side. The clipping method is well known simple method to enable the reduction of PAPR performance by clipping the larger amplitude level of transmission OFDM signal at the transmission side. Although the clipping method can achieve the better PAPR performance, this method produces newly the clipping noise which causes the degradation of BER performance. The DAR method was proposed to compensate the clipping noise in which the clipping noise is reconstructed at the receiver side by using the decision data information. However the DAR method can only mitigate the clipping noise and not for the non-linear distortion occurring in the non-linear amplifier.

To solve the above problem on the conventional DAR method, this research proposes the Improved DAR (IDAR) method, which can mitigate both the clipping noise and inter-modulation noise. In the proposed IDAR method, the characteristics of non-linear amplifiers are required to be known at the receiver for mitigating the inter-modulation noise. This research also proposes the estimation method for AM-AM and AM-PM conversions characteristics of non-linear amplifiers by using low PAPR (Peak to Averaged Power Ratio) preamble symbols. This research presents two example systems which employ the proposed IDAR method in the wireless LAN system and the broad band satellite communication systems. From the computer simulation results, it is concluded that the proposed IDAR method can achieve the higher transmission data rate and higher efficient usage of non-linear power amplifier with keeping the better BER performance even in the non-linear channel.

4. Concluding remarks

This research proposed the solutions for PAPR problems. These proposed methods could be mainly categorized into two types of methods; 1) to reduce the PAPR to extend possible at the transmission side, and 2) to compensate the non-linear distortion at the receiver side.

First type, the common name can be called by PAPR reduction methods. The PAPR performance is required to reduce as more as possible before inputted to the HPA at the transmitter side. All of PAPR reduction methods can improve both for the spectral growth and BER performance for OFDM technique in the wireless communications. This research proposes two PAPR reduction methods by using dummy sub-carriers. The proposed methods can achieve better PAPR and BER performances with less complexity than conventional method. These methods suitable for low cost receiver because it have no required additional circuits. The conventional OFDM receiver can work with these methods.

Second type, this research proposes the IDAR method that can work well both for WLAN and satellite channel. In the simulation results show that the proposed method can improve BER performance and efficient usage of HPA. The proposed method can achieve higher transmission data rate than single carrier modulation in the satellite channel by using multi-level QAM. To realize in the practical system, research also proposes the non-linear characteristic estimation method that the non-linear amplifier characteristics in the IDAR method is required to be known at the receiver.

The multi-level QAM have capability to improve the transmission data rate, however have very sensitivity to the non-linearity of HPA such as 64QAM. The last chapter proposed combination between PAPR reduction and IDAR methods. The proposed method can employ multi-level QAM in the satellite channel. The simulation results show that the proposed methods show the higher data transmission rate and better BER performance than single carrier modulation.

As a conclusion of researches in this research, the proposed PAPR reduction methods and mitigation methods of non-linear distortion noise could provide various practical solutions for next generation of multimedia wireless communications systems employing the OFDM technique.

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Ergonomic Study on VDT Workstation Design
for Decreasing Workload

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Keywords: VDT, Workstation, System design, Multi display, Display height, Workload

1. Introduction

In this study, the height and the number of the liquid crystal display (LCD) were discussed to propose the ergonomic design for visual display terminal (VDT) workstation that is able to decrease the workload of VDT operators. There were two kinds of studies in the doctor's thesis. The first study was to decide the appropriate height of LCD, and the second study was to discuss the number of the LCD, with using multi display type VDT.

In order to design the ideal VDT workstation, these VDT operations were analyzed by work efficiency, work posture, electromyogram (EMG) activities and subjective assessment in ergonomic aspects.

2. Appropriate height of LCD in VDT work

The appropriate heights of LCD, including a notebook personal computer (NPC), were discussed by analyzing of work posture and EMG activities of neck muscles of VDT operators. The comparative experiments were carried out in each experimental condition.

Results were as follows. It is necessary to separate the display of NPC from the keyboard and central processing unit (CPU). The position of the NPC display prevents the head from inclining forward, while maintaining an adequate viewing distance. The height of the display should be adjusted to each user with 1200 mm as an upper limit. The appropriate height can be estimated by summing of the sitting height and the chair height of each user. Moreover, a manuscript stand should be attached to the display in data entry tasks to prevent poor posture.

3. Characteristics of multi LCD type VDT

The characteristics of multi display VDT was evaluated by the analyses of work performance, subjective assessment, work posture, EMG activities, critical fusion frequency (CFF), NASA Task Load Index (NASA-TLX) and subjective symptoms of fatigue.

Results were as follows. Work efficiency of the single LCD was inferior compared to multi LCD and large one. The multi display type VDT workstation was evaluated highly, in visibility and operability, than the single display. A head moved wider for the system with multi LCD than those with a single LCD and large one. EMG activities did not differ significantly in all experiment conditions. Fatigue and workload of multi LCD did not differ significantly than single LCD.

4. Conclusion

The appropriate height of LCD and the multi LCD were examined to design the comfortable VDT workstation for decreasing workload. These design requirements are going to obtain ergonomic data applicable to the guidelines and recommendation for VDT operations.

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Development of A Flexible Structural Force Sensor and Application to A Robot Hand

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1. The purpose

The aim of this research is to develop a flexible structural force sensor which is mounted on a surface of a fingertip of a robot hand and to examine feasibility of new dexterous tasks by the sensor. The sensor's flexibility is modeling on a human finger cushion. This research describes a structure and fundamental characteristics of measurement of the flexible sensor and several applications about object grasping by a robot hand which installed the sensor on its finger.

2. Outline of the flexible structural force sensor

In this research, we propose a new type of force sensor. This sensor can measure a contact location ϕ_C and four-axis contact forces which are consisted of a vertical force F_Z, two-axis shearing forces F_X, F_Y and a rotational moment around the contact point M_C. This sensor structure is shown in Figure 1. This sensor consists of two parts: a contact part and a measurement part. The contact part is an arch beam that is made of silicon rubber. Silicon rubber is an elastic material, so the contact part is easily deformed.

On the other hand, the measurement part consists of four beams and a support part. When a contact force is transmitted from the contact part to the measurement part, these beams are deformed depending on the amount of contact force or the direction of the contact force.

Figure 1: Structure of the flexible force.

Four-axis contact forces are calculated in terms of the amount of these deformations which are measured by strain gages ε_{X1}, ε_{X3}, ε_{Z1} and ε_{Z3} on the beam of the measurement part.

3. Characteristics of measurement

A contact location and four-axis contact forces are determined with the use of some equations which are derived based on Castigliano's theorem and simple analysis model of the contact part which is included all of dimensions and material characteristics of the sensor. Validity of equations for determines these information and measurement accuracy are confirmed experimentally. One of the experimental results is shown as Figure 2. This result shows that desired values and experimental results are advisable agreement.

In addition, this sensor can also calculate four-axis deformations of the flexible contact part of the sensor. Deformations of the contact part are determined with the use of measurement result of each contact force.
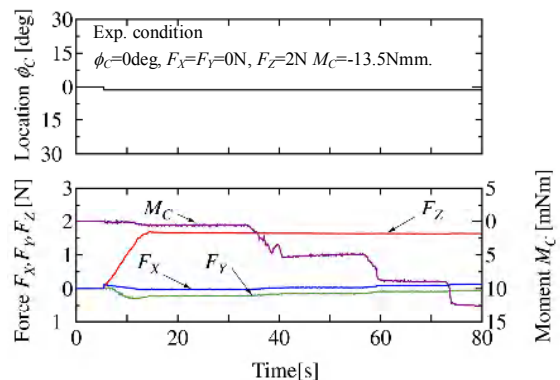

Figure 2: Experimental results of a contact location and four-axis contact force measurement.

4. Applications

4-1. Object grasping against translational and rotational slippage

The issue of translational and rotational slippage that occurs when a robot hand grasps an object is discussed. To grasp an object against each directional slippage is important for a dexterous task realization. In this application, a sufficient conditional expression to grasp an object against translational and rotational slippage is presented. This expression is derived based on the consideration of a contact area between a flexible contact part and object's surface such as Figure 3 which occurs the sensor is pressed to the object. An effectiveness of the expression is confirmed experimentally with the use of a translational gripper where the flexible contact sensor is mounted. Figure 4 shows experimental result of object grasping. From this result, it is confirmed that grasping force is increasing with increasing translational force and rotational moment. On the other hand, object's position does not change approximately. Therefore, it is confirmed that the robot hand can grasp against translational and rotational slippage.
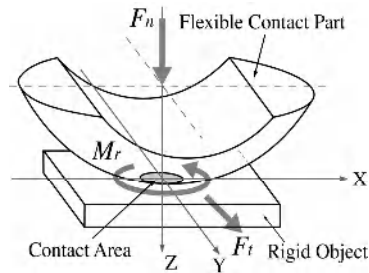

Figure 3: A contact area between the flexible contact part of the sensor and an object.
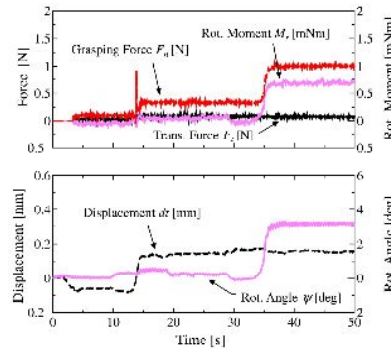

Figure 4: Experimental results of object grasping against translational and rotational slippage.

4-2. Object placing with a low impulsive force

A placing motion of a grasped object by a robot hand equipped with the sensor on the finger is discussed. The aim of this application is to realize a quick placing motion with the impulsive force between the object and the floor small. To derive a dynamic model of the motion, we consider the deformation of the flexible sensor occurring when the hand grasps the object. The dynamic model represents the relationship between the impulsive force and an approaching trajectory of the robot hand to the floor. From this model, we can obtain the trajectory of the hand which ensures that the impulsive force is less than the object's own weight.

Figure 5 and Figure 6 show that the experimental results of placing motion. From Figure 5, it is confirmed that the robot hand position is approximately same as a desired trajectory which is obtained by the model, and the sensor deformation is decreased. From Figure 6, it is confirmed that a reaction force is less than the object's weight. Therefore, it is confirmed that the hand equipped the flexible sensor can put down the grasping object with low impulsive force.
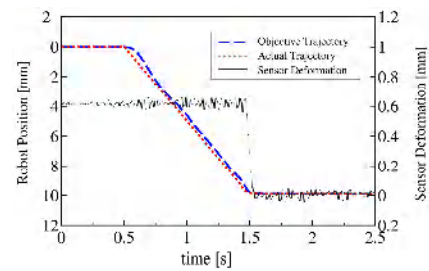

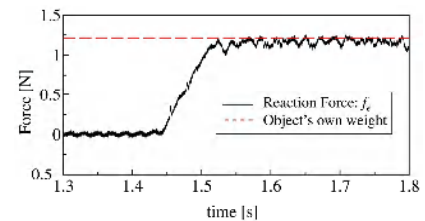Figure 5: Experimental result of robot position and sensor deformation.

Figure 6: Experimental result of reaction force from the floor.

5. Conclusion

In this research, we proposed a new type of force sensor which has a flexible contact mechanism. This sensor can measure a contact location and four-axis contact forces.

An effectiveness of this flexible structural force sensor demonstrated through two applications. These results of application suggest that the robot hand which has a flexible contact part on its finger surface can perform dexterous tasks.

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Estimation on The Amount of Movement Lines of Material Transportation with Systematization of The Information and Material Management
- A study on the facility management of hospital architecture -

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This paper aims at the hospital architecture offering essential medical services. The foremost tasks of hospital architecture are to contribute to the sound management and to maintain the high functional levels in the long run. To settle these issues, facility management is thought to be quite effective.

Medical services by doctors and nurses include not only treatment directly for patients but also consequential chores. Increasing the latter means decreasing the quality of medical treatment. Under the financial pressure, hospital managers must save life cycle cost. When hospital architecture is planned, flows of people, articles and information are considered to be indicators. These flows need to be investigated closely, and to be improved so that medical staff can take more time in the direct medical treatment. They have to reduce the burden of moving around, to diminish the stress of indirect consequential chores, and to save and simplify their labors. It can be also successful in financial management. Targeting material transportation, the medical information system and the material management and supply system, to systematize the movement of materials and information enables hospitals to control effectively. This means achieving greater efficiencies in management and medical treatment.

The purpose of this study is as follows; one is to organize a hospital supporting system and to suggest what to evaluate; another is to estimate the amount of movement lines, which have been made more efficient by a hospital supporting system and a department arrangement. Some previous work have reported the flows of materials, the movement of the transporter, the amount of transportation, the department arrangements, and the estimation of plan type and so on. Generally speaking, the contents of the most previous work can be divided into hospital management and architectural space. In this study, the medical information system and material management and supply system are treated systematically. Considering the movement lines as an indicator, hospital management and architectural space are treated comprehensively in the Chapter 1.

In the first half of the second chapter and in the third chapter, the first purpose of this study is achieved. One example of hospital supporting system, i. e. ordering system has been investigated in the survey questionnaires. The results of the survey show that the interlock of the doctor's processing order and accounting procedure is distinguishing. Two difficulties are still left; how to make it a standard and how to abolish many kinds of tickets and vouchers. The evolution items concerning what to introduce first are as follows; first, where many systems are adopted-[B: prescription and checkup], [C' : B plus medical radiation], [C: C' plus injection], and [E: C plus interlocking accounting]; second, how many tickets and vouchers are eliminated-[I: many], [II: few], and [III: none]. A pattern of [E-III] is the most systematic. Also interviews are conducted at four hospitals. As a result, it is revealed that plural systems are introduced. The types of the material management and supply system are depend on the combination of supply methods, management methods, and planar forms of supplying section. From the actual conditions of those four hospitals, three typical models are derived. Making an allowance for the introduction of the POS system and the material management at consumption of each model are simulated.

The latter half of the second chapter and the Chapter 4 treat the connection with departments. The patterns of department arrangement have developed with systemization of the medical information system. In the pattern of E-III, characteristically the flow of job cards has replaced that of web orders. The common materials are pick up from a flow chart of supplying operation and presented as a flow modeling. Examined qualitatively, the flows of articles and supplies in three models are estimated.

In the Chapter 5, the amount of transportation between each department is figured out. Another research on transportation is conducted at the hospitals for three days. The results shows that the conveyance during the

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daytime on weekdays occupies 70 % of the whole, and that increase in scheduled transport makes the number of transporting operations decrease. The rate of transportation load by the types of transportation is demonstrated.

The amount of movement lines of materials are calculated in the Chapter 6. That of each hospital is different, but by establishing the medical information system, it can be reduced by about 25 to 50 %, and when the material management and supply systems are added, it can be cut by more 39 %, and when the POS system is added, by 50 %. It is concluded that the material management and supply systems are effective in providing the easy access, and that three models are successful in helping the medical staff to shorten the walking distance and the POS system in helping the administrative staff. More two points are clarified; an intensive supplying sections needs ingenuity of department arrangement in order to lessen the movement lines; and dispersive supplying section should systematize the material management service.

The seventh chapter deals with the flow of staff and patients in hospital ward. Another inquiry has done at the foregoing hospitals. According to the results of the survey, it is determined that nurses walk around more than 4 kilometer during the working hours. Most of the destinations are nurse station to exchange information, document the nursing record, and so on. At the other destinations, they give patients treatment and talk with their families. And it has revealed that the locations of nursing activities are in a gradual composition. The combinations of the materials and facilities are examined and the results show that the hospital supporting system can decentralize working locations and shorten the movement lines. Moreover, even the existing hospitals can make improvements.

The position in facility management (FM) of this research product is considered in the next chapter and estimated through the viewpoints of space and systems, which is one of the methods for evaluation of FM productivity. One characteristic of hospital architecture is that a hospital has plural systems. Systematization not only in each department but also between departments can make the flows and transportation easier. In each department, nursing service and the hospital supporting system are connected closely and the system should be typical and customized. In the hospitals used for a long term, which needs more flexible systems, the model 3 and the POS system are promising. The space arrangement under the influence of systematization is the positional relation between demanding spaces and supplying spaces. Scattering the supplying spaces can cut down the amount of movement lines. On the other hand, concentrating them make it easier to upgrade systems and renovate. In the case of the POS system, because out-of-hospital carriers are involved in the transporting service, hospitals needs high security and the simple and quick access to demanding places from the outside.

Another example of FM in hospital architecture is functional estimation. In order to maintain the level of systems, periodical and uncomplicated checking is significant. When the material arrangement is not considered for nursing service in a unit of a hospital ward, it might not be consistent with its hospital supporting system and need to reassemble the whole system.

Three points are left for the future investigation; first, exploration in the United States about the development of the POS system; second, simulation of the changing service in a nursing ward by grading the hospital supporting system; third, establishment of screening self-diagnosis in a practical way.

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Motion tracking of
left ventricular myocardium using ultrasound

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Keyword: Ultrasonic diagnosis system, Myocardial motion tracking

1 Introduction

The echocardiogram is an essential tool for diagnosis and treatment of cardiovascular diseases. The use of echocardiograms for clinical diagnosis serves clinitians and doctors with multifold advantages including noninvasiveness of diagnosis and real–time imaging. Recent technical innovations of ultrasonic diagnosis equipment reclaim their new availabilities in clinics. These novel modalities require to track a specific tissue of myocardium to keep their focus on a relevant tissue to evaluate. In this research, four novel algorithms, that aim to contribute for these new availabilities of ultrasonic in diagnosis, are investigated.

2 Automatic Extraction of Left Ventricular Endocardium

Automatic extraction of left ventricular endocardium in echocardiograms is required for quantitative evaluation of the functional performance of the left ventricle. In this section, a novel automatic extraction method based on double thresholding for echocardiograms is proposed, and its effectiveness and the accuracy are evaluated. B-mode echocardiograms are first binarized with a threshold determined by the discriminant analysis for the gray level histogram. Then the binary images are contracted n times to remove small regions and to disconnect the region of cardiac cavity from the other false regions. Among the obtained regions which corresponds to the cardiac cavity is selected and dilated $2n$ times to create a mask which restricts the region of the second thresholding operation. The size and the location of the cardiac cavity in the preceding frame are utilized to select the corresponding region. The masked image of each frame is binarized in the restricted area in the same way as in the first thresholding operation. The evaluation test is carried out using the scatter diagram of radius of contours extracted by two observers and automatic extraction method. These results showed that the accuracy of the extracted contours was favorably compared to the accuracy of manually traced contours.

3 Automatic Tracking for Regional Myocardial Motion

In this section, an automatic tracking method for 2-D motion of Regional myocardial motion in high-frame rate echocardiography by using the correlation method with connective multiple ROIs is proposed. The proposed method is a combination method of maximization for correlation of brightness distribution and optimization the geometric location of ROIs. A comparison test of tracking accuracies between the

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conventional method and proposed one is carried out. Results of these tests shows that proposed method is able to derive more accurate trajectories from echocardiography than conventional method.

4 Local Myocardial Motion Tracking Using Ultrasonic Doppler Signal

In this section, a new method for automatically tracking the motion of local region in left ventricular myocardium by means of ultrasonic pulsed Doppler signal is proposed. This method consists of a velocity detection procedure based on correlation weighted mean instantaneous phase difference and a motion tracking procedure employing a elastic model. Most of ultrasonic pulsed Doppler signals contain considerable amount of speckled noise, which causes detection error of velocity. The procedure of correlation weighted mean velocity is aimed to reduce the velocity detection error, and the elastic model is used to avoid the accumulation of the error to keep track of the motion of the myocardium in reasonable accuracy.

5 Local Myocardial Motion Tracking Using Ultrasonic RF Signal

This section describes a new algorithm to track identical myocardium accurately through a few cardiac cycles. Hierarchical correlation is used with wide correlation window as first and narrow one as second. Then, to increase the reliability of the estimated position of myocardial motion, neighboring points are weighted by correlation coefficients of ultrasonic waveforms between sequential pulses and are summed up. This method was applied to normal and diseased hearts. Tracking error during one cardiac cycle decreased to one-fifth of simple method and the stability increased substantially. Regional myocardial strains in the wall were estimated and color-coded using this tracking method. Result: this strain image revealed clearly the differences of myocardial function between endocardium and epicardium, and the specific characters of myocardial diseases. Moreover, the cyclic variation of integrated backscatters is automatically obtained using this tracking method. This cyclic variation also indicated the myocardial tissue characters of diseased heart in terms of ultrasonic backscatter intensity.

6 Conclusions

In this research, new modalities to track the myocardial motion from echocardiogram. The proposed approaches are able to increase the performance of motion tracking. These methods contribute to provide new applications of ultrasonic for diagnosing cardiovascular diseases.

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