Journal of Organometallic Chemistry, 356 (1988) 125–131
Elsevier Sequoia S.A., Lausanne – Printed in The Netherlands

Reactions of $PhCOPdX(PPh_3)_2$ (X = I, Cl) with alkylmetals under carbon monoxide; formation of α-diketones and α-hydroxyketones under stoichiometric and catalytic conditions

Hiroshi Yamashita, Toshi-aki Kobayashi, Toshiyasu Sakakura and Masato Tanaka *

National Chemical Laboratory for Industry, Tsukuba, Ibaraki 305, (Japan)

(Received October 17th, 1987; in revised form April 23rd, 1988)

Abstract

The reactions of $PhCOPdX(PPh_3)_2$ (Ia: X = I; Ib: X = Cl) with alkylmetals under carbon monoxide have been investigated. The reactivity of ethylmetals toward Ia was found to decrease in the order: Et_2M (M = Zn, Cd, Hg) ~ EtZnCl ~ EtCu > EtMgBr ~ EtMnI ~ Et_3Al > Et_2AlCl > Et_3B ~ Et_4Sn (no reaction). In these reactions, the simple coupling product, PhCOEt (II) and/or the carbonylative coupling products IIIa–IIIc (IIIa: PhCOCOEt; IIIb: PhCEt(OH)COEt; IIIc: $PhCOCEt_2(OH)$) were formed depending on the nature of the ethylmetal. Et_2Hg and Et_3Al gave exclusively II. EtMgBr, EtCu, and EtZnCl gave both of II and III. EtMnI and Et_2M (M = Zn, Cd) selectively gave III. The use of Ar_2Zn (Ar = Ph, *p*-Tol) in place of Et_2Zn gave decreased yields of the carbonylative coupling products. The palladium complex Ib showed almost the same reactivity toward Et_2Zn as Ia. Further to this palladium-catalyzed carbonylation reactions of PhCOCl with alkylmetals were examined. The reaction with Et_2Zn catalyzed by $PdCl_2(PR_3)_2$ (R = Ph, *p*-FC_6H_4) afforded III (mainly IIIb and IIIc, about 200%/Pd). The combination of $Pd(PPh_3)_4$ and Et_3Al more effectively afforded III (mainly acyloin-type reduced products, about 900%/Pd).

Introduction

Palladium-catalyzed coupling of acyl halides with organometallic reagents of Sn, Zn, and Al has been one of the important methods for ketone synthesis [1–6]. In addition, some carbonylative coupling reactions of organic halides with organometallics under carbon monoxide pressure are also available now [7]. In these reactions an acylpalladium species is generally presumed to be formed as a key intermediate, but its reactivity toward organometallics, in particular under carbon monoxide, has

0022-328X/88/$03.50

Table 1

Reactions of $PhCOPdI(PPh_3)_2$ (Ia) with ethylmetals under carbon monoxide [a]

Entry	Ethylmetal (EtM)	Recovered Ia [b] (%)	Yield [c] (%)		
			PhCOEt	PhCOCOEt	PhCEt(OH)COEt + $PhCOCEt_2(OH)$
1	Et_4Sn	99	0	0	0
2	Et_3B	99	0	0	0
3	Et_2AlCl	86	1	0	0
4	Et_3Al	82	15	0	0
5	EtMnI [d]	70	trace	3	trace
6	EtMgBr	67	8	5	trace
7	EtCu [d]	0	21	12	17
8	EtZnCl [d]	0	56	0	21
9	Et_2Zn	0	9	22	6 [e]
10	Et_2Zn [d]	0	4	7	68
11	Et_2Cd [d]	0	2	8	71
12	Et_2Hg [d]	0	91	0	0

[a] Reaction conditions: Ia 0.05 mmol, ethylmetal 0.1 mmol, THF 2.5 ml (THF/hexane (v/v 24/1) 2.5 ml for entries 2, 3, 4, and 9; Et_2O 2.5 ml for entry 5), CO 30 atm (at −50 °C), room temperature 2 h. [b] Estimated by IR. [c] Yield based on charged Ia. [d] The reaction was effected in the presence of 0.1 mmol MgBrI (entry 5 and 7), 0.1 mmol MgClBr (entry 8) or 0.2 mmol MgClBr (entries 10, 11, and 12) in situ generated during the preparation of the ethylmetal reagents. [e] PhCH(OH)COEt and PhCOCHEt(OH) were also formed (23%).

not been extensively investigated. We have already reported on the reactions of $PhCOPdX(PPh_3)_2$ (X = I, ClO_4) with alcohols under carbon monoxide in relation to the mechanism of palladium-catalyzed double carbonylations of aryl halides which yield α-keto esters [8,9]. We have extended our study to the reactions of $PhCOPdX(PPh_3)_2$ (Ia: X = I; Ib: X = Cl) with various alkylmetals under carbon monoxide, and have found that α-diketones and further alkylated products (α-hydroxy ketones) are formed in some cases. Attempts to effect the carbonylative coupling of PhCOCl with alkylmetals catalytically by palladium complexes are also described.

Results and discussion

Reactions of $PhCOPdI(PPh_3)_2$ (Ia) with ethylmetal reagents under carbon monoxide

To examine the influence of metals in alkylmetal reagents, Ia was allowed to react with various ethylmetals under carbon monoxide (35 atm) at room temperature (Table 1). The simple coupling product II, and carbonylative coupling products, PhCOCOEt (IIIa), PhCEt(OH)COEt (IIIb), and $PhCOCEt_2(OH)$ (IIIc) were formed (eq. 1). In some cases benzaldehyde was also formed in small amounts

$$\begin{array}{l} PhCOPdI(PPh_3)_2(Ia) + CO + EtM \rightarrow \\ \qquad \underset{(II)}{PhCOEt} + \underset{(IIIa)}{PhCOCOEt} + \underset{(IIIb)}{PhCEt(OH)COEt} + \underset{(IIIc)}{PhCOCEt_2(OH)} \qquad (1) \\ (EtM = \text{ethylmetal}) \end{array}$$

(< 2%). The product distribution and the reaction rate (consumption of Ia) varied significantly depending on the ethylmetal used. Thus, the ethyl derivatives of Sn, B, Al, Mn, and Mg did not show high reactivity under the present conditions. On the other hand, the reaction with Et_2Hg was rapid, but selective formation of propiophenone resulted. Of the ethylmetals examined, only those of Cu, Zn, and Cd gave carbonylative coupling products, III, in appreciable amounts. In particular, the reaction with Et_2Zn or Et_2Cd in the presence of a magnesium salt * was most selective to the carbonylative coupling, though the main product was not IIIa, but IIIb and IIIc. Addition of the magnesium salt promotes the addition of Et_2Zn to ketones as was previously suggested [10].

On the basis of studies previously published [11–16], the formation of III is presumably rationalized by the reaction sequence which involves (benzoyl)(propionyl)palladium species (IV) and its reductive elimination, as outlined in eq. 2.

$$\mathrm{PhCOPdIL_2 + CO + EtM} \rightarrow \underset{(\mathrm{IV})}{[\mathrm{(PhCO)Pd(COEt)L_2}]} \rightarrow$$

$$\underset{(\mathrm{IIIa})}{\mathrm{PhCOCOEt}} \xrightarrow{\mathrm{EtM}} \underset{(\mathrm{IIIb})}{\mathrm{PhCEt(OH)COEt}} + \underset{(\mathrm{IIIc})}{\mathrm{PhCOCEt_2(OH)}} \qquad (2)$$

$(\mathrm{L = PPh_3,\ EtM = ethylmetal})$

After reaction IR spectrum of each mixture showed absorption bands at 1849, 1868, 1894, and 2024 cm^{-1}. The absorption at 1849 cm^{-1} is presumably due to the bridging carbonyl of $Pd_3(CO)_3(PPh_3)_3$ [17]. The assignment of the other bands is ambiguous, but these are also thought to arise from mono- or poly-nuclear carbonylpalladium(0) species. Accordingly, when benzoyl chloride was added, these bands disappeared and a new band ascribable to $PhCOPdCl(PPh_3)_2$ (Ib) appeared at 1646 cm^{-1}. These observations suggest the possibility to effect the carbonylative coupling of benzoyl chloride with organometallic reagents using palladium complexes as catalysts (vide infra).

Reactions of $PhCOPdX(PPh_3)_2$ ($X = I$, Cl) with diorganozinc reagents and the effects of the reaction conditions

Since Et_2Zn afforded good yields of the carbonylative coupling products III, factors which may have affected the reaction of diorganozincs were examined. The results are summarized in Table 2.

In the reaction of Ia with Et_2Zn, a decrease in the carbon monoxide pressure from 30 to 10 atm did not cause much difference. But the content of benzaldehyde increased with further decrease in CO pressure, and under nitrogen, benzaldehyde was predominantly formed. Its formation is presumably due to the reaction of Ia with Et_2Zn to give an (ethyl)(benzoyl)palladium intermediate, that undergoes β-hydride abstraction, with subsequent reductive elimination of benzaldehyde from the resulting (hydrido)(benzoyl)palladium species as outlined in eq. 3.

$$\mathrm{PdCOPdIL_2 + Et_2Zn \rightarrow PhCOPd(Et)L_2 \rightarrow PhCOPd(H)L_2 \rightarrow PhCHO} \qquad (3)$$

$(\mathrm{L = PPh_3})$

In a previous paper on the mechanism of the double carbonylation, we examined the reaction of Ia with alcohols in the presence of triethylamine, and reported that

---

* The magnesium salt was generated in situ during the preparation of the ethylmetal reagents using EtMgBr and zinc or cadmium chloride salts. Use of salt-free Et_2Zn in the presence of added $MgBr_2$ gave the same result.

Table 2

Reactions of $PhCOPdX(PPh_3)_2$ (Ia: X = I; Ib: X = Cl) with R_2Zn (R = Et, Ph, *p*-Tol) under carbon monoxide [a]

Entry	Pd complex	R	*P*(CO) (atm)	Additive (mmol)	Yield [b] (%)			
					PhCHO	PhCOR	PhCOCOR	PhCR(OH)COR + $PhCOCR_2(OH)$
10	Ia	Et	30	–	trace	4	7	68
13	Ia	Et	10	–	3	5	11	62
14	Ia	Et	1	–	21	6	16	24
15	Ia	Et	0 [c]	–	63	8	0	0
16	Ia	Et	30	PPh_3 (0.4)	2	5	5	81
17	Ia	Et	30	$P(OMe)_3$ (0.2)	0	1	14	66
18	Ia	Ph	30	–	0	58	40	trace
19	Ia	*p*-Tol	30	–	0	54 [d]	31	trace
20	Ib	Et	30	–	3	9	8	61

[a] Reaction conditions were the same as those for entry 10; see footnotes to Table 1. [b] Yield based on charged Ia or Ib. [c] Carried out under nitrogen. [d] $(p\text{-Tol})_2CO$ was also formed (0.005 mmol).

the addition of extra PPh_3 enhanced the selectivity to the carbonylated products, e.g. α-keto esters (vs. simple esters) at the expense of the reaction rate [9]. However, in the present reaction, the favorable effect by the extra PPh_3 for the formation of III was only marginal. On the other hand, the addition of $P(OMe)_3$ seemed to suppress the formation of II and doubled the relative amount of IIIa, though there is no clear reason for this.

When Et_2Zn was replaced with Ph_2Zn or $(p\text{-Tol})_2Zn$ in the reaction with Ia, a large amount of the simple coupling product (ketone) was formed, and the amounts of carbonylative coupling products decreased. In addition, α-diketones were almost the sole carbonylative coupling product, along with traces of arylated products. This is probably due to the weak nucleophilicity of the diarylzinc reagents.

In the reaction of $PhCOPdX(PPh_3)_2$ with methanol in the presence of triethylamine, the product distribution (PhCOCOOMe vs. PhCOOMe), has been found to depend significantly on the identity of X (Cl, I) [18]. However, in the present reaction, Ib gave nearly the same distribution as Ia.

Attempted synthesis of α-diketone derivatives via catalytic carbonylative coupling of PhCOCl with ethylmetals

The palladium complexes such as $PdCl_2(PR_3)_2$ when treated with carbon monoxide, ethylmetals, and PhCOCl, are expected to be transformed into $PhCOPdCl(PR_3)_2$ via the reaction given (eq. 4). In addition, we have learned that the complexes Ia and Ib react with Et_2Zn and carbon monoxide to yield

$$PdCl_2L_2 \xrightarrow{CO,\ EtM} PdCl(COEt)L_2 \xrightarrow[-Et_2CO,\ \text{etc.}]{EtM} [PdL_2] \xrightarrow{PhCOCl} PhCOPdClL_2 \quad (4)$$

($L = PR_3$; EtM = ethylmetal)

the carbonylative coupling products (α-diketone derivatives) and palladium(0) species. The latter was readily converted back to Ib when treated with PhCOCl. These considerations and results combined led us to examine the catalytic synthesis

Table 3

Reactions of PhCOCl with R_2Zn (R = Et, Ph, *p*-Tol) under carbon monoxide in the presence of palladium complexes [a]

Entry	R	Pd complex	Yield [b] (%)			
			PhCHO	PhCOR	PhCOCOR	PhCR(OH)COR + $PhCOCR_2(OH)$
21	Et	$PdCl_2(PCy_3)_2$ [c]	27 (3)	753 (75)	< 5 (< 0.5)	6 (1)
22	Et	$PdCl_2(PMe_3)_2$	0 (0)	993 (99)	0 (0)	0 (0)
23	Et	$PdCl_2(PhCN)_2$	0 (0)	28 (3) [e]	0 (0)	0 (0)
24	Et	$PdCl_2(PPh_3)_2$	74 (7)	232 (23)	24 (2)	171 (17)
25	Et	$PdCl_2[P(p\text{-}FC_6H_4)_3]_2$	77 (8)	145 (15)	11 (1)	196 (20)
26	Et	$PdCl_2(dppb)$ [d]	17 (2)	511 (51)	6 (1)	72 (7)
27	Ph	$PdCl_2(PPh_3)_2$	0 (0)	732 (73)	56 (6)	< 5 (< 0.5)
28	*p*-Tol	$PdCl_2(PPh_3)_2$	0 (0)	479 (48) [f]	15 (2)	< 5 (< 0.5)

[a] Reaction conditions: PhCOCl 0.5 mmol, R_2Zn 1 mmol, MgClBr 2 mmol, Pd complex 0.05 mmol, THF 20 ml, CO 30 atm, room temperature 16 h. [b] Yield based on the Pd complex. Figures in parentheses are yields based on charged PhCOCl. [c] Dichlorobis(tricyclohexylphosphine)palladium. [d] Dichloro[1,4-bis(diphenylphosphino)butane]palladium. [e] $PhCO_2(CH_2)_4Cl$ was also formed (22%/PhCOCl). [f] $(p\text{-Tol})_2CO$ was also formed (0.12 mmol).

of α-diketone derivatives using $PdCl_2(PR_3)_2$ as the catalyst. The results are summarized in Table 3.

The outcome of the catalyzed reactions of PhCOCl with Et_2Zn under carbon monoxide was significantly dependent on the nature of phosphine ligand of the catalyst. Complexes of strongly-bound phosphines such as $P(cyclo\text{-}C_6H_{11})_3$, PMe_3, and dppb were better catalysts for simple coupling (formation of ketone), but not for the carbonylative coupling. The phosphine-free complex, $PdCl_2(PhCN)_2$, showed no activity for carbonylative coupling. PPh_3 and $P(p\text{-}FC_6H_4)_3$, the coordination of which to palladium is not too strong or too weak, were found to be the best ligands in terms of the selectivity, and the α-diketone derivatives were formed in about 200%/Pd combined yield. The PPh_3 complex, when used in the reaction with Ph_2Zn or $(p\text{-Tol})_2Zn$, promoted simple coupling, but not carbonylative coupling.

Although the formation of α-diketone derivatives from PhCOCl, Et_2Zn, and carbon monoxide proceeded catalytically with respect to palladium, the efficiency was not satisfactory. Hence, we further examined the carbonylative coupling using other ethylmetal reagents. As a result, it turned out that the reaction with Et_3Al in the presence of $Pd(PPh_3)_4$ afforded the α-diketone derivatives in about 900%/Pd combined yield (eq. 5) *.

$$\mathrm{PhCOCl} + \mathrm{Et_3Al} + \underset{(70\ \mathrm{atm})}{\mathrm{CO}} \xrightarrow[\text{room temperature, 46 h}]{\mathrm{Pd(PPh_3)_4},\ \text{THF-hexane}}$$

$$\underset{393\%/\mathrm{Pd}}{\mathrm{PhCOEt}} + \underset{61\%/\mathrm{Pd}}{\mathrm{PhCOCOEt}} + \underbrace{\mathrm{PhCEt(OH)COEt} + \mathrm{PhCOCEt_2(OH)}}_{125\%/\mathrm{Pd}}$$

$$+ \underbrace{\mathrm{PhCH(OH)COEt} + \mathrm{PhCOCHEt(OH)}}_{\sim\ 710\%/\mathrm{Pd}} \qquad (5)$$

---

* The acyloin-type reduced products were readily converted into the α-diketone when oxidized with $Cu(OAc)_2$; see Experimental.

Complex Ib is probably involved in the catalysis. However, the analogous complex Ia did not undergo the carbonylative coupling when treated with Et_3Al under carbon monoxide (Table 1). These somewhat puzzling results may have arisen from the difference in conditions; the catalytic reaction was run using 0.4 *M* Et_3Al in THF/hexane (v/v 3/2) under 70 atm of carbon monoxide while the stoichiometric reaction was carried out using 0.04 *M* Et_3Al in THF/hexane (v/v 24/1) under 30 atm of carbon monoxide. The concentration of Et_3Al and the degree of its complexation with the various solvents are known to affect the monomer–dimer equilibrium [19]. An increase in the carbon monoxide pressure promotes the coordination of carbon monoxide to the palladium center. Accordingly, it is possible that the use of different conditions (variation of the concentration, the solvent, and the pressure) caused the change in reactivity of Et_3Al and the palladium complex.

Although the catalytic efficiency is low, and the mechanistic details have not been elucidated, the results reported herein should open up the field of the carbonylative coupling of acid halides with carbon nucleophiles.

Experimental

Infrared spectra were recorded on a Jasco A-302 spectrometer. Mass spectral determinations were made by use of a Shimadzu QP-1000 GC-MS spectrometer (70 eV).

Solvents and organic halides were dried by standard methods and distilled under nitrogen or in vacuo. Et_4Sn was prepared by a published procedure [20]. Hexane solutions (1 *M*) of Et_3B, Et_2AlCl, Et_3Al, and salt-free Et_2Zn were used as purchased. Other alkylmetals were prepared by the reaction of Grignard reagents with suitable inorganic salts in THF and were used without removal of the magnesium salts. $PhCOPdI(PPh_3)_2$ [21] and $PhCOPdCl(PPh_3)_2$ [22] were prepared as reported.

All the reaction products were identified by the comparison of GC retention times with those of authentic samples and/or by the analysis of the MS fragmentation patterns of the product. The amount of product in each case was estimated by GC using internal standards.

The spectral data of PhCEt(OH)COEt, which was prepared by the reaction of PhCOCOEt with Et_2Zn, are as follows; ^1H NMR ($CDCl_3$): 1.88 (t, *J* 7.2 Hz, CH_3), 1.93 (t, *J* 7.2 Hz, CH_3), 2.21 (q, *J* 7.2 Hz, CH_2), 2.39 (q, *J* 7.2 Hz, CH_2), 4.54 (s, OH), 7.24–7.64 (m, C_6H_5) ppm; IR (neat): 1706 (C=O), 3490 (OH) cm^{-1}; MS *m/e* (intensity): 57 (100), 135 (65).

Reactions of $PhCOPdX(PPh_3)_2$ (Ia: $X = I$; Ib: $X = Cl$) with alkylmetals under carbon monoxide (Tables 1 and 2)

A typical procedure is as follows; to complex Ia (0.05 mmol) placed in an autoclave equipped with a glass insert, was added under nitrogen THF (2 ml) and CO at a pressure of 20 atm was introduced. After the autoclave had been cooled at −50 °C, the carbon monoxide was discharged. A THF solution of Et_2Zn (0.2 *M*, 0.5 ml) containing MgClBr (about 0.2 mmol) was added under a stream of CO and 30 atm of CO was introduced. The cooling bath was removed, and the mixture was stirred at room temperature for 2 h. After CO had been discharged, the reaction mixture was acidified with saturated aqueous solution of NH_4Cl (3 ml) and the products were extracted with ether (30 ml). The ether layer was concentrated, and the products were analyzed by GC-MS and GC, which revealed the formation of PhCOEt (4%), PhCOCOEt (7%), and PhCEt(OH)COEt + $PhCOCEt_2(OH)$ (68%, about 6/1 mixture) with a trace amount of PhCHO.

Reactions of PhCOCl with R_2Zn (R = Et, Ph, p-Tol) under carbon monoxide in the presence of palladium complexes (Table 3)

The procedure is similar to that described above. To a palladium catalyst (0.05 mmol) placed in an autoclave, THF (17 ml) and PhCOCl (0.5 mmol) was added at room temperature under nitrogen. After a THF solution of Et_2Zn (0.33 *M*, 3 ml) was added at − 50 °C, the mixture was stirred at room temperature for 16 h.

Reaction of PhCOCl with Et_3Al under carbon monoxide in the presence of $Pd(PPh_3)_4$

To $Pd(PPh_3)_4$ (0.05 mmol) placed in an autoclave equipped with a glass insert, THF (3 ml), PhCOCl (1.76 mmol), and a hexane solution of Et_3Al (1 *M*, 2 ml) were added under nitrogen at room temperature. Carbon monoxide (70 atm) was introduced, and the mixture was stirred for 46 h. After the usual work-up, the products were analyzed by GC-MS and GC, which revealed the formation of the compounds shown in eq. 5. Then, the reaction mixture was dissolved in 70% AcOH (3 ml), and $Cu(OAc)_2$ (1 mmol) was added. The resulting mixture was stirred at 100 °C for about 1 h. After further work-up, the products were analyzed to reveal almost quantitative transformation of the acyloin-type reduced products into PhCOCOEt (758%/Pd, 22%/PhCOCl).

References

1 R.F. Heck, Palladium Reagents in Organic Syntheses, Academic Press Inc., London, 1985, p. 316 and p. 362.
2 D. Milstein and J.K. Stille, J. Org. Chem., 44 (1979) 1613, and ref. cited therein.
3 T. Sato, K. Naruse, M. Enokiya and T. Fujisawa, Chem. Lett., (1981) 1135.
4 E. Negishi, V. Bagheri, S. Chatterjee, F. Luo, J.A. Miller and A.T. Stoll, Tetrahedron Lett., 24 (1983) 5181.
5 R.A. Grey, J. Org. Chem., 49 (1984) 2288.
6 K. Wakamatsu, Y. Okuda, K. Oshima and H. Nozaki, Bull. Chem. Soc. Jpn., 58 (1985) 2425.
7 T. Kobayashi and M. Tanaka, Tetrahedron Lett., 27 (1986) 4745, and ref. cited therein.
8 H. Yamashita, T. Kobayashi, T. Sakakura and M. Tanaka, J. Mol. Catal., 40 (1987) 333.
9 H. Yamashita, T. Sakakura, T. Kobayashi and M. Tanaka, J. Mol. Catal., 48 (1988) 69.
10 B. Marx, É. Henry-Basch and P. Fréon, C.R. Acad. Sci., Paris, Sér. C, 264 (1967) 527.
11 F. Ozawa and A. Yamamoto, Chem. Lett., (1981) 289.
12 F. Ozawa, T. Sugimoto, Y. Yuasa, M. Santra, T. Yamamoto and A. Yamamoto, Organometallics, 3 (1984) 683.
13 F. Ozawa, T. Sugimoto, T. Yamamoto and A. Yamamoto, Organometallics, 3 (1984) 692.
14 F. Ozawa, H. Soyama, H. Yanagihara, I. Aoyama, H. Takino, K. Izawa, T. Yamamoto and A. Yamamoto, J. Am. Chem. Soc., 107 (1985) 3235.
15 J.-T. Chen and A. Sen, J. Am. Chem. Soc., 106 (1984) 1506.
16 A. Sen, J.-T. Chen, W.M. Vetter and R.R. Whittle, J. Am. Chem. Soc., 109 (1987) 148.
17 K. Kudo, M. Hidai and Y. Uchida, J. Organomet. Chem., 33 (1971) 393.
18 Y. Yamashita and M. Tanaka, unpublished result.
19 M.B. Smith, J. Organomet. Chem., 46 (1972) 211.
20 W.J. Jones, D.P. Evans, T. Gulwell and D.C. Griffiths, J. Chem. Soc., (1935) 39.
21 P.E. Garrou and R.F. Heck, J. Am. Chem. Soc., 98 (1976) 4115.
22 K. Suzuki and M. Nishida, Bull. Chem. Soc. Jpn., 46 (1973) 2887.