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Condensation of Diethyl Acetonedicarboxylate. III.[1] Isolation and Acylation of Diethyl Acetonedicarboxylate-Magnesium Complex

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Diethyl acetonedicarboxylate (DADC)-magnesium complex, $(DADC)_2Mg$ (**5b**), was isolated from the reaction of DADC and $MgCl_2$ with Et_3N, or by the removal of coordination water from $(DADC)_2Mg \cdot 2H_2O$ (**5a**). Compound **5b** could be regarded as an intermediate in the selfcondensation of DADC to give **1**, **2**, **3**, and **4**. A mechanism is proposed for the formation of these products from **5b**.

Acylation of **5a**, **b** was carried out. The reaction of **5b** with acyl chloride gave the monoacylated DADC (**9**) as the main product. The reaction of **5a**, **b** with diketene afforded diethyl homophthalate (**4**) and orsellinic acid (**11**) derivatives, formed by acylation and subsequent cyclization.

Keywords——diethyl acetonedicarboxylate; magnesium; diethyl homophthalates; γ-pyrones; diketene; metal chelate complex; condensation; acylation

It is known that the selfcondensation of diethyl acetonedicarboxylate (DADC) in the presence of ethyl chloroacetate (ECA) and magnesium as catalysts gives two types of products according to the amount of these catalysts used: when a large quantity of these catalysts relative to the amount of DADC is used, diethyl 4-carboxy-3,5-dihydroxyhomophthalate (**1**)[2a] and ethyl 4-carboxyorsellinate (**2**)[2b] are obtained, while the use of a small quantity of these catalysts in the same reaction affords diethyl 4-ethoxycarbonyl-3,5-dihydroxyhomophthalate (**3**)[2a] and diethyl 3,5-dihydroxyhomophthalate (**4**)[2b] as the main products (Chart 1).

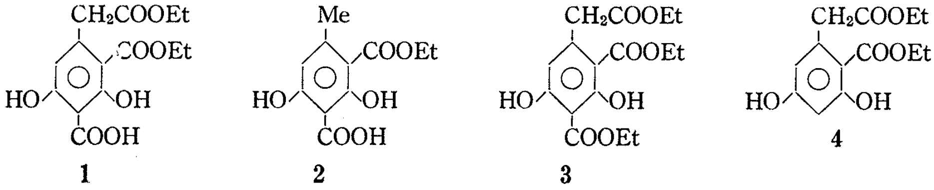


Chart 1

We studied the mechanism of these reactions in order to find the best conditions for the synthesis of **1**, **2**, **3**, and **4** and discussed the roles of these catalysts, magnesium and ECA.[1] Namely, a complex, $(DADC)_2Mg \cdot 2H_2O$ (**5a**) (Chart 2), isolated from the reaction of DADC and magnesium with ECA, was first considered to be an intermediate in the formation of **1**, **2**, **3**, and **4**, but this assumption was later modified because heating of **5a** afforded **1** in a poor yield. Therefore, a presumptive intermediate, DADC–Mg–ECA (**6**), was proposed as the real intermediate, in the formation of these products in the previous paper.[1] However, it is now considered that the previous assumption was corrected and that the real intermediate is not **6** but $(DADC)_2Mg$ (**5b**),[3] which simply lacks the coordination water of **5a**. This conclusion was supported by the following results. Recently, **5b** was obtained as a viscous oil by the elimination of coordination water from **5a** as the benzene azeotrope, or by heating of a mixture of DADC, anhydrous magnesium chloride, and triethylamine in dry benzene. On heating **5b** for 30 min at 180°, **1** and **2** were obtained in 39.3 and 6.7% yields, respectively. On the other hand, heating of a mixture of **5b** (2.4 mmol) and excess DADC (19.8 mmol) for 3 hr at

180° afforded **3** and **4** in 30.1 and 8.1% yields, respectively. These yields were calculated based on DADC.

Complex **5b** is so hygroscopic that it changes rapidly to crystalline **5a** on standing in air or on the addition of water. The past failure to identify the real intermediate[1] seems to be due to the fact that **5b** could not be isolated because of its strongly hygroscopic nature.

The mechanism of formation of **1** and **3** from **5b** is proposed to be as shown in Chart 3, which suggests that **1** and **2** are formed by the type A reaction mechanism, while the type B reaction mechanism accounts for the formation of **3** and **4** (Chart 3).

We next found a simplified method for the preparation of **1** and **2** without the formation of polymerized by-product, that is, heating of **5a** in dry xylene at 140° with there moval of volatile products by azeotropic distillation.

The role of ECA in the selfcondensation of DADC was reported as that of dissolving magnesium, so as to facilitate the formation of DADC-magnesium complex.[1] This assumption was based on the following results: when a mixture of DADC (24.7 mmol) and magnesium (51.4 mmol) was heated in the absence of ECA, **3** was obtained in 10.7% yield together with **1**, **2**, and **4** in poor yields. On the other hand, heating of a mixture of DADC (24.7 mmol) and magnesium (51.4 mmol) in the presence of ECA (16.3 mmol) afforded **1** in 34.1% yield together with **2**, **3**, and **4** in poor yields.[2a]

In the present work, gas chromatography of the volatile compounds formed in the course of heating of a mixture of DADC, ECA, and magnesium at 180° showed the presence of ethyl acetate together with ethanol and acetone. However, on the gas chromatogram of the volatile compounds obtained in the course of heating of a mixture of DADC and magnesium, a peak of ethyl acetate was not detected. These results indicated that the ethyl acetate was formed from ECA used and suggested the role of ECA in the formation of **5b** to be as shown in Chart 2.

Copper, zinc, and calcium complexes of DADC were prepared and heated under the conditions used for the simplified preparation of **1** from **5a** described above. Although heating of $(DADC)_2Zn \cdot 2H_2O$ (**5c**$\cdot 2H_2O$) or $(DADC)_2Ca \cdot 2H_2O$ (**5d**$\cdot 2H_2O$) gave **1** and **2**, heating of $(DADC)_2Cu$[3] (**5e**) gave **3** and **4** in 24.5 and 3.0% yields, respectively (Table I). These differing results may be due to differences in the ability of individual metals to form the chelate compound. A difference in the reactions of **5a**, **5c**, and **5d**, and that of **5e** was observed: on heating **5e**, a precipitate of copper oxide appeared during the course of the reaction, but no such precipitate was observed in the case of **5a**, **5c**, or **5d**. The reaction of **5a**, **5c**, or **5d** probably proceeded through mechanism A, while that of **5e** might proceed through mechanism B (Chart 3).

On heating a mixture of **5b** and ethyl acetoacetate, an increasing yield of **2** was observed, while heating of a mixture of **5b** and ethyl benzoylacetate gave ethyl 3-carboxy-6-phenyl-β-resorcylate (**7**). These results indicated that **2** was formed not by the bimolecular conden-

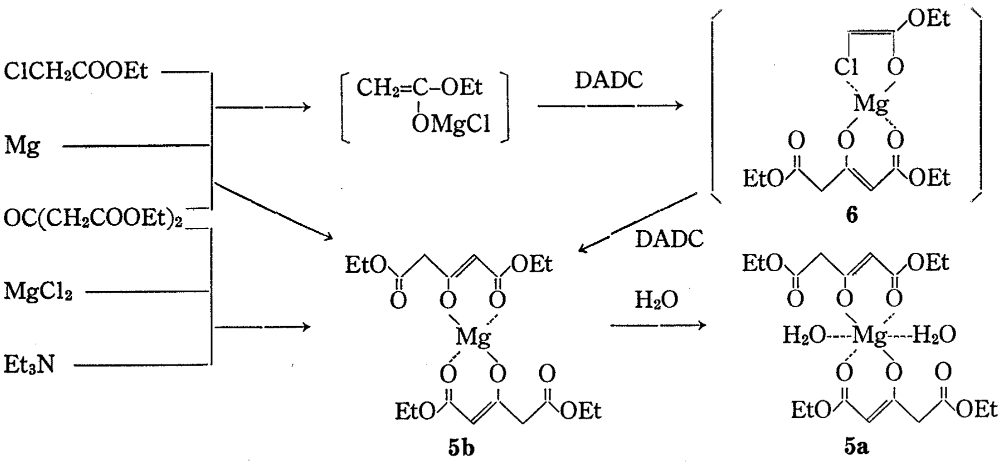


Chart 2

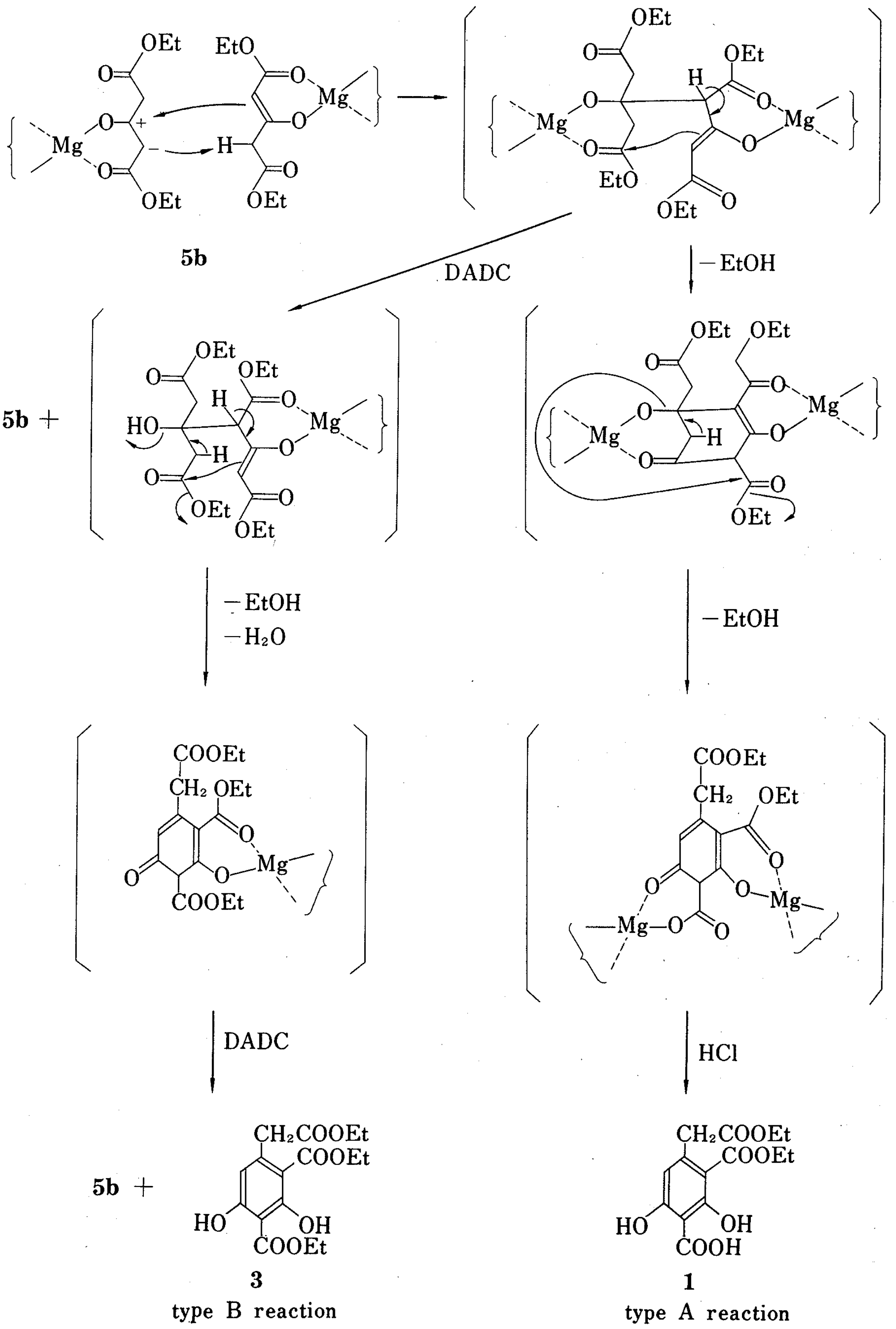
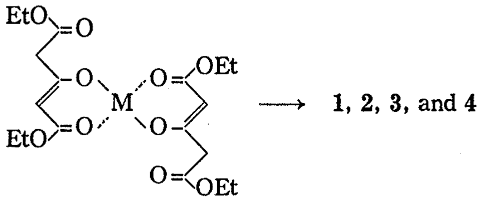


Chart 3

sation[1] of DADC but by the reaction of **5b** with ethyl acetoacetate formed by decomposition of DADC in the course of this reaction.

Muramoto *et al.*[4] reported the regioselective alkylation of DADC in the presence of magnesium ethoxide, and stated that the methylene group in the side chain of the chelate ring of $(DADC)_2Mg$ could be methylated, while the methine group in the chelate ring was inactive. However, we found here that the methine group in the chelate ring of **5a** or **5b** was sufficiently reactive to be acylated by acyl chloride or acyl anhydride to give a monoacylated product,

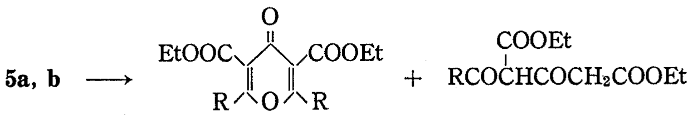
Table I. Reaction of DADC-Metal Complex



Compd. No.	M	Yield (%)[a] 1	2	3	4
5b	Mg	39.3	6.7	—	—
5c	Zn	21.9	0.8	—	—
5d	Ca	29.3	—	—	—
5e	Cu	—	—	24.5	3.0

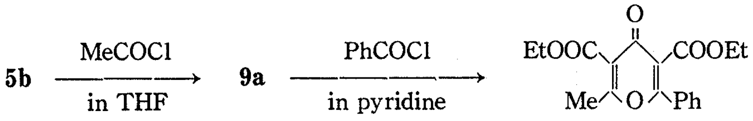
[a] Reaction time, 30 min, reaction temperature, 180°.

Table II. Acylation of **5a, b**



8 **9**

a: R=Me **a**: R=Me
b: R=Ph **b**: R=Ph
c: R=CH$_2$Ph



10

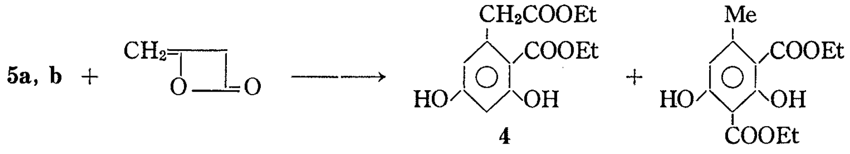
Compd. No.	R	Acylating agent	Solvent	Temp. (°C)	Time (hr)	Yield (%) 8	9
5a	Ph	PhCOCl	Pyridine	r. t.[a]	24	30.7	—
5a	Me	$(MeCO)_2O$	$(MeCO)_2O$	100	0.25	61.0	—
5b	Me	$(MeCO)_2O$	$(MeCO)_2O$	r. t.	60	0.2	18.0
5b	Ph	PhCOCl	Benzene	r. t.	65	3.3	—
5b	Ph	PhCOCl	THF	r. t.	24	4.2	43.9
5b	Me	MeCOCl	THF	r. t.	24	0.9	62.5
5b	$PhCH_2$	$PhCH_2COCl$	THF	r. t.	24	—	68.5

[a] Room temperature.

ethyl α-acylacetonedicarboxylate (**9a**—**c**) and/or a diacylated product, γ-pyrone (**8a, b**) (Table II). The reaction of **5b** with an equimolar amount of acetyl chloride in tetrahydrofuran (THF) gave, **9a** as a main product. Furthermore, the treatment of **9a** with an equimolar amount of benzoyl chloride in pyridine gave 3,5-diethoxycarbonyl-2-methyl-6-phenyl-4*H*-pyran-4-one (**10**), formed by the cyclization of an unsymmetrical diacyl-DADC (Table II). Such regioselective mono- and/or diacylation of **5a** or **5b** seemed to be due to the increasing nucleophilicity of the methine group in the chelate ring.

Stirring of a solution of **5a** or **5b** and diketene in THF at room temperature gave **4** and 2,4-diethoxycarbonylorcinol (**11**). The yields of these products depended on the reaction conditions (Table III).

Table III. Reaction of **5a, b** with Diketene



4 **11**

Compd. No.	Catalyst[a]	Yield (%) 4	Yield (%) 11
5a	—	15.3	5.9
5b	—	26.3	9.5
5b	NaH	5.7	4.7
5b	Et_3N	3.0	17.6

a) Solvent, THF; reaction temperature, room temperature; reaction time, 20 hr.

Experimental

Melting points (determined on a Yanagimoto micromelting point apparatus) are uncorrected. NMR spectra were taken with a Hitachi R-22 FTS spectrometer at 90 MHz, with tetramethylsilane as an internal standard. MS spectra were recorded on a Shimadzu LKB-9000 spectrometer, and IR spectra on a Nippon-bunko A-102 spectrometer.

$(DADC)_2Mg$ (5b)——Method A: A mixture of diethyl acetonedicarboxylate (DADC) (10 g, 50 mmol), Et_3N (5 g, 50 mmol), and anhyd. $MgCl_2$ (2.4 g, 25 mmol) in dry benzene was refluxed until the mixture became clear. The solution was concentrated *in vacuo* and cooled to room temperature. Dry Et_2O was added to the solution, and the resulting precipitate was filtered off and washed with dry Et_2O. The filtrate and washings were collected and concentrated *in vacuo* to give **5b** (9.5 g, 85%) as a pale yellow viscous oil. IR $\nu_{\max}^{\text{Nujol}}$ cm^{-1}: 1710, 1645, 1563, 1530. NMR (in $CDCl_3$) δ: 1.21 (12H, t, $J=7$ Hz, CH_3), 3.09 (4H, s, CH_2COO), 4.07 (8H, q, $J=7$ Hz, $\underline{H}_2$ $C\underline{H}_2CH_3$), 4.72 (2H, s, CH).

Method B: A suspension of $(DADC)_2Mg\cdot 2H_2O$ (**5a**) (5 g, 11 mmol) in dry benzene (50 ml), prepared according to the method described in the previous paper,[1] was heated with removal of H_2O by azeotropic distillation to give **5b** in quantitative yield. Complex **5b** is very hygroscopic: when a solution of **5b** in dry Et_2O was allowed to stand in air, a precipitate appeared gradually. The precipitate was found to be identical with authentic **5a** by comparison of mp, NMR spectra, and MS. Furthermore, addition of H_2O to **5b** gave crystals of **5a** immediately.

$(DADC)_2Zn\cdot 2H_2O$ (5c·2H₂O)——DADC (10 g, 50 mmol) was added to an aqueous solution of $ZnCl_2$ (3 g, 25 mmol). Aqueous NH_3 was added to the mixture with stirring until a precipitate was deposited at pH 8—10. The mixture was stirred for 1 hr, then the precipitate was filtered off, washed with H_2O, and recrystallized from EtOH to give **5c**·$2H_2O$ (5.1 g, 47%), mp 64—66°. *Anal.* Calcd for $C_{18}H_{30}O_{12}Zn$: C, 42.91; H, 6.00. Found: C, 42.59; H, 5.58. IR $\nu_{\max}^{\text{Nujol}}$ cm^{-1}: 1700, 1620, 1500. NMR (in $CDCl_3$) δ: 1.30 (12H, t, $J=7$ Hz, CH_2CH_3), 2.20—2.50 (4H, b, H_2O), 3.22 (2H, s, CH), 3.63 (4H, s, CH_2COO), 4.29 (8H, q, $J=7$ Hz, $C\underline{H}_2CH_3$).

$(DADC)_2Ca\cdot 2H_2O$ (5d·2H₂O)——Compound **5d**·$2H_2O$ was prepared as described for the synthesis of **5c**·$2H_2O$. Yield: 57%. mp 70—71°. *Anal.* Calcd for $C_{18}H_{30}CaO_{12}$: C, 45.18; H, 3.62. Found: C, 45.03; H, 6.33. IR $\nu_{\max}^{\text{Nujol}}$ cm^{-1}: 1700, 1640, 1520. NMR (in $CDCl_3$) δ: 1.21 (6H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 1.25 (6H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 2.75—3.00 (4H, b, H_2O), 3.16 (4H, s, CH_2COO), 4.07 (4H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 4.16 (4H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 4.70 (2H, s, CH).

$(DADC)_2Cu$ (5e)——Compound **5e** was prepared according to the method of Muramoto *et al.*[4] *Anal.* Calcd for $C_{18}H_{26}CuO_{10}$: C, 46.40; H, 5.62. Found: C, 46.35; H, 5.47.

Gas-Liquid Chromatography——Apparatus and Conditions: A Shimadzu GC-3B gas chromatograph equipped with a flame ionization detector was used. The operating conditions for GC were follows: liquid phase, Octoil-S (25%); solid support, 60—80 mesh Shimalite; column, 1.7 m × 3 mm, glass; column temperature, 80°; injection and detector port temperature, 260°; carrier gas (N_2) pressure, 0.65 kg/cm^2; hydrogen pressure, 0.60 kg/cm^2; air pressure, 0.55 kg/cm^2.

Preparation and Identification of GC Sample: A mixture of DADC (10 g, 50 mmol), Mg (2.5 g, 104 mmol), and ECA (3 g, 25 mmol) was heated for 30 min at 180° while volatile products were collected in a cold flask. One μl of the volatile compounds (sample A) was injected into the gas chromatograph. Sample B was obtained by the treatment of a mixture of DADC (10 g, 50 mmol) and Mg (2.5 g, 104 mmol) in a similar manner. The peaks of the samples were identified by comparison with those of commercial special grade AcOEt, Me_2CO, and EtOH. The peak of AcOEt was detected on the gas chromatogram of sample A, but not on that of sample B.

Condensation of DADC-Metal Complex (Type A Reaction)——DADC-metal complex (**5b**—**e**) was suspended in dry xylene and heated for 30 min at 180° with mechanical stirring while volatile products were removed by azeotropic distillation. The reaction mixture was acidified with dil. HCl and extracted with AcOEt. The AcOEt layer was washed with H_2O and dried over $MgSO_4$. The solvent was evaporated off, and the residue was separated by column chromatography on silica gel using benzene–CH_2Cl_2 for elution. The products were identified by comparison with authentic samples[2b] (thin–layer chromatography and mp). The yields of the products are listed in Table I.

Condensation of 5b with DADC (Type B reaction)——A mixture of **5b** (1.0 g, 2.4 mmol) and DADC (4.0 g, 19.8 mmol) was heated for 3 hr at 180°. The resulting mixture was treated as described above and column chromatographed on silica gel. Elution with benzene–CH_2Cl_2 gave **3** (1.28 g, 30.1%) and **4** (0.27 g, 8.1%), which were identified by comparison of the IR and NMR spectra with those of authentic samples.

Preparation of 1 and 2 by Condensation of 5a——A mixture of **5a** (5.0 g, 10.8 mmol) in dry xylene was heated for 1.5 hr at 140° while volatile products were removed by azeotropic distillation. The reaction mixture was treated as described above. Column chromatography on silica gel (benzene–CH_2Cl_2) of the reaction mixture gave **1** (1.37 g, 40.8%) and **2** (0.43 g, 18.5%). The products **1** and **2** were identified by comparison with authentic samples.[2b]

Condensation of 5b in the Presence of Ethyl Acetoacetate——A mixture of **5b** (1.8 g, 4.3 mmol) and ethyl acetoacetate (1.2 g, 4.3 mmol) was heated for 30 min at 180°. The reaction mixture was treated as described above. Column chromatography on silica gel (benzene–CH_2Cl_2) of the reaction mixture gave **1** (0.16 g, 11.7%) and **2** (0.23 g, 10.7%).

Ethyl 3-Carboxy-6-phenyl-β-resorcylate (7)——A mixture of **5b** (2.7 g, 6.5 mmol) and ethyl benzoylacetate (1.2 g, 6.5 mmol) was heated for 2 hr at 180°. The reaction mixture was treated as described above. Column chromatography on silica gel (benzene–CH_2Cl_2) of the reaction mixture gave **1** (0.34 g, 16%), **2** (0.09 g, 5.7%), and **7** (0.26 g, 6.4%). **7**: mp 144—145° (from CH_2Cl_2–cyclohexane). *Anal.* Calcd for $C_{16}H_{14}O_6$: C, 62.09; H, 4.86. Found: C, 62.22; H, 4.65. IR ν_{max}^{Nujol} cm^{-1}: 1675, 1670. NMR (in $CDCl_3$) δ: 0.79 (3H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 4.05 (2H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 6.55 (1H, s, C_5H), 7.14—7.44 (5H, m, Ar–H), 10.20—12.45 (1H, b, OH). MS *m/e*: 302 (M^+), 284 (M^+-H_2O), 256 (M^+-EtOH).

Acylation of 5a, b——Method A: A solution of **5a** (1 g, 2.2 mmol) in acetic anhydride was heated for 15 min at 100°. The reaction mixture was concentrated under reduced pressure, made basic with sat. $KHCO_3$ solution, and extracted with AcOEt. The AcOEt layer was washed with H_2O, dried over $MgSO_4$, and concentrated *in vacuo*. The residue was recrystallized from CH_2Cl_2–cyclohexane to give 3,5-diethoxycarbonyl-2,6-dimethyl-4*H*-pyran-4-one (**8a**) (0.72 g, 61%), mp 79° (79—80°[5]). IR ν_{max}^{Nujol} cm^{-1}: 1715, 1650, 1620. NMR (in $CDCl_3$) δ: 1.33 (6H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 2.36 (6H, s, C_2– and C_3–CH_3), 4.31 (4H, q, $J=7$ Hz, $C\underline{H}_2CH_3$).

Method B: Acetyl chloride (0.67 g, 8.5 mmol) was added to a solution of **5b** (1.8 g, 4.3 mmol) in dry THF, and the mixture was stirred for 24 hr at room temperature, then acidified with dil. HCl and extracted with AcOEt. The AcOEt layer was washed with H_2O, dried over $MgSO_4$, and concentrated *in vacuo*. Column chromatography of the residue on silica gel using Et_2O–petr. ether (1: 3) as eluent gave diethyl α-acetylacetonedicarboxylate (**9a**) (1.2 g, 62%) and **8a** (21 mg, 0.9%). **9a**: bp 146—149° (0.15 mmHg). *Anal.* Calcd for $C_{11}H_{16}O_6$: C, 54.09, H, 6.60. Found: C, 54.31; H, 6.82. IR ν_{max}^{Nujol} cm^{-1}: 1740, 1720, 1675. NMR (in CCl_4) δ: 1.26 (6H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 2.44 (3H, s, $COCH_3$), 3.70 (2H, s, $COCH_2$), 4.15 (2H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 4.22 (2H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 17.97 (1H, s, enol-OH). MS *m/e*: 224 (M^+), 199 (M^+-OEt). 3,5-Diethoxycarbonyl-2,6-diphenyl-4*H*-pyran-4-one (**8b**) and diethyl α-benzoylacetonedicarboxylate (**9b**) were obtained by the reaction of **5b** with benzoyl chloride in dry THF in a similar manner. **8b**: mp 143.5—144.5° (from CH_2Cl_2–cyclohexane). *Anal.* Calcd for $C_{23}H_{20}O_6$: C, 70.40; H, 5.14. Found: C, 70.16; H, 5.29. IR ν_{max}^{Nujol} cm^{-1}: 1715, 1650, 1620, 1600. NMR (in $CDCl_3$) δ: 1.28 (6H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 4.25 (4H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 7.35—7.77 (10H, m, Ar–H). MS *m/e*: 392 (M^+). **9b**: bp 98—104° (0.05 mmHg). *Anal.* Calcd for $C_{16}H_{18}O_6$: C, 62.74; H, 5.92. Found: C, 62.88; H, 5.89. IR ν_{max}^{Nujol} cm^{-1}: 1740, 1720, 1690. NMR (in $CDCl_3$) δ: 1.25 (3H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 1.28 (3H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 3.23 (2H, s, $COCH_2$), 4.15 (4H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 7.30—8.02 (5H, m, Ar–H), 17.88 (1H, s, enol-OH). MS *m/e*: 306 (M^+). Similarly, diethyl α-(phenylacety)acetonedicarboxylate (**9c**) was obtained by the reaction of **5b** with phenylacetyl chloride in dry THF. bp 175—176° (0.1 mmHg). *Anal.* Calcd for $C_{17}H_{20}O_6$: C, 63.74; H, 6.29. Found: C, 63.93; H, 6.13. IR ν_{max}^{Nujol} cm^{-1}: 1740, 1720, 1690, 1600. NMR (in $CDCl_3$) δ: 1.22 (3H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 1.25 (3H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 3.67 (2H, s, CH_2COO), 4.08 (2H, s, $C\underline{H}_2C_6H_5$), 4.11 (2H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 4.17 (2H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 7.22 (5H, s, Ar–H), 17.72 (1H, s, enol–OH). MS *m/e*: 320 (M^+).

3,5-Diethoxycarbonyl-2-methyl-6-phenyl-4*H*-pyran-4-one (10)——Acetyl chloride (0.67 g, 8.5 mmol) was added to a solution of **5b** (1.8 g, 4.3 mmol) in dry THF, and the mixture was stirred for 24 hr at room temperature. Dry pyridine (5 ml) was then added dropwise to the solution and the mixture was stirred for 1 hr. Next, benzoyl chloride (2 g, 14 mmol) was added and the whole was stirred for 24 hr. The reaction mixture was acidified with dil. HCl and extracted with AcOEt. The AcOEt layer was washed with H_2O, dried over $MgSO_4$, and concentrated *in vacuo*. Column chromatography of the residue on silica gel with CH_2Cl_2 gave **10** (1.1 g, 40%), which was recrystallized from CH_2Cl_2–cyclohexane, mp 103—103.5°. *Anal.* Calcd for $C_{18}H_{18}O_6$: C, 65.44; H, 5.49. Found: C, 65.14; H, 5.18. IR ν_{max}^{Nujol} cm^{-1}: 1740, 1725, 1650, 1620. NMR (in $CDCl_3$) δ: 1.14 (3H, t, $J=7$ Hz, $CH_2C\underline{H}_3$), 1.34 (3H t $J=7$ Hz $CH_2C\underline{H}_3$), 2.48 (3H, s, CH_3), 4.24 (2H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 4.38 (2H, q, $J=7$ Hz, $C\underline{H}_2CH_3$), 7.40—7.75 (6H, m, Ar–H). MS *m/e*: 330 (M^+).

Reaction of 5b with Diketene——Method A: Diketene (1.8 g, 21.6 mmol) was added dropwise to a solution of **5b** (4.5 g, 10.8 mmol) in dry THF with cooling an ice-water bath. The mixture was stirred for 20 hr at room temperature, acidified with dil. HCl and extracted with AcOEt. The AcOEt layer was washed with H_2O, dried over $MgSO_4$, and concentrated *in vacuo*. Column chromatography of the residue on silica gel with benzene gave **11** (0.55 g, 9.5%). Further elution with CH_2Cl_2 afforded **4** (1.5 g, 26%). The NMR spectra and melting points of **11** and **4** were identical with those reported by Sudzuki *et al.*[6]

Method B: Et_3N (0.9 g, 8.6 mmol) was added to a solution of **5b** (1.8 g, 4.3 mmol) in dry THF, and the mixture was stirred for 10 min at room temperature. Then, diketene (1.5 g, 17.3 mmol) was added dropwise with cooling in an ice-water bath and the mixture was treated as described above. The compounds **11** and **4** were obtained in 17.6% (0.2 g) and 3.0% (35 mg) yields, respectively.

References and Notes

1) Part II: M. Yamato, J. Uenishi, and K. Hashigaki, *Chem. Pharm. Bull.*, **26**, 1973 (1978).
2) *a)* D.S. Jerdan, *J. Chem. Soc.*, **75**, 808 (1899); *b)* M. Yamato, J. Uenishi, and K. Hashigaki, *Chem. Pharm. Bull.*, **26**, 1459 (1978).
3) Muramoto *et al.* reported the preparation of the DADC-Mg complex formulated as $(DADC)_2Mg$ by the treatment of DADC with magnesium ethoxide, and stated that the complex gave diethyl 2-alkylacetonedicarboxylate on treatment with alkyl bromide. However, the mp, and nuclear magnetic resonance (NMR) and infrared (IR) spectra of the complex were found to be identical with those of **5a** isolated by us. Y. Muramoto, K. Ōishi, I. Ichimoto, and H. Ueda, *Nippon Nogeikagaku Kaishi*, **48**, 507 (1974).
4) Y. Muramoto, K. Ōishi, I. Ichimoto, and H. Ueda, *Nippon Nogeikagaku Kaishi*, **47**, 201 (1973).
5) M. Conrad and M. Guthzeit, *Chem. Ber.*, **19**, 19 (1886).
6) E. Sudzuki, B. Katsuragawa, and S. Inoue, *J. Chem. Soc. Perkin I*, **1977**, 72.