Synthesis via 2-Acylmethyl-2-oxazoline. I. A Novel Synthesis of 3-Acyl-2-pyridones by Michael Addition of 2-Acylmethyl-2-oxazoline to α,β-Acetylenic Ketones

Yasuo Tohda,* Takeshi Yanagidani, Shin-ichi Hiramatsu, Nagatoshi Nishiwaki,† Keita Tani, Kazuko Imagawa, and Masahiro Ariga†

Laboratory of Organic Chemistry, Division of Natural Science, Osaka Kyoiku University, Asahigaoka 4-698, Kashiwara, Osaka 582

†Department of Chemistry, Osaka Kyoiku University, Asahigaoka 4-698, Kashiwara, Osaka 582

(Received June 9, 1997)

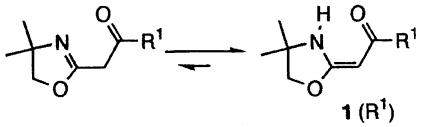
The reaction of the sodium salt of 2-acylmethyl-4,4-dimethyl-2-oxazolines with α,β-acetylenic ketones in ethanol gave Michael adducts, which were easily transformed to 4,6-disubstituted 3-acyl-1-(2-hydroxy-1,1-dimethylethyl)-2-pyridones by silica gel. *N*-Dealkylation of the pyridones was performed using hydrochloric acid in good yields. Deacylation of the pyridones was performed using potassium hydroxide. A mild treatment of the pyridones with bases or silica gel gave 7-oxa-1-azabicyclo[4.3.0]non-3-en-2-one derivatives via intramolecular Michael addition. A similar reaction of 2-phenacyl-2-oxazoline with diphenylpropynone gave the corresponding 1-(2-hydroxyethyl)-2-pyridone derivative, which was inert against these 1-dealkylation, 3-deacylation, and intramolecular addition reactions.

It is well known that β-keto esters are useful in synthetic organic chemistry and that 2-oxazoline can be transformed to a variety of functional groups, e.g., acid,[1] ester,[2] lactone,[3] aldehyde,[4] ketone,[5] and carboxamide.[6] Therefore, 2-acylmethyl-2-oxazoline, which is a 2-oxazoline derivative of β-keto ester, is expected to be a versatile synthetic intermediate. Previously, we reported on convenient preparation methods of 2-acylmethyl-2-oxazolines by the acylations of 2-alkyl-2-oxazolines with acid chlorides which have no α-hydrogens,[7] or with acid anhydrides which have α-hydrogens in the presence of aluminum chloride.[8] Recently, Castan reported on the preparation of 2-acylmethyl-2-oxazolines by the reaction of enamines with 2-chloroethyl isocyanate.[9]

Here, we wish to report on a new convenient synthesis of 3-acyl-2-pyridones starting from a Michael addition of 2-acylmethyl-4,4-dimethyl-2-oxazolines (**1**) to α,β-acetylenic ketones (**2**). The synthesis of a functionalized 2-pyridone ring continues to be a topical area of interest because of the number of biologically important molecules that contain this moiety,[10] and because the ring can be easily converted to a pyridine ring.[11] Although many methods for the synthesis of functionalized 2-pyridones have been developed,[12] the construction of 3-acyl-2-pyridone has been scarcely reported.[13] This method is very useful for the synthesis of functionalized 2-pyridones, because both reagents **1** and **2** are easily available. Thus, α,β-acetylenic ketones (**2**) are prepared by some coupling reactions of terminal acetylenes with acid derivatives[14] according to the Sonogashira reaction[15] or some other methods.[16] The reagents are also obtained by the oxidation[17] of acetylenic alcohols.[18]

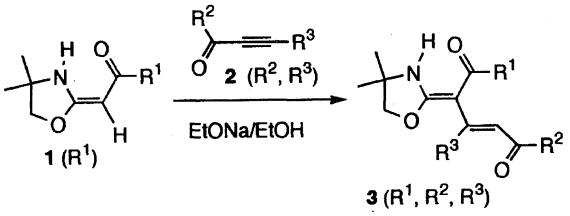
Results and Discussion

Although we call **1** (R^1) 2-acylmethyl-2-oxazoline for convenience, their ^1H, ^{13}C NMR, and IR spectra show that most of them exist in an enamine form, and that 2-acylmethyl-2-oxazoline itself is present in a minor tautomer in deuteriochloroform (Eq. 1). The enamine tautomer is assigned as ketene *N,O*-acetal, rather than 2-(2-hydroxyethenyl)-2-oxazoline, because the ^{13}C NMR spectra of **1** indicate the presence of a ketonic carbonyl carbon at a lower field (188—204 ppm). The structure is in agreement with prior assignments for related compounds.[1,9,19,20]



(1)

The reaction of 2-acetonyl-4,4-dimethyl-2-oxazoline (**1**(Me)) with diphenylpropynone (**2** (Ph_2)) by a catalytic amount of NaOEt in ethanol gave an expected Michael adduct, 2-(1-acetyl-4-oxo-2,4-diphenyl-2-butenylidene)-4,4-dimethyloxazolidine (**3** (Me, Ph_2)), as orange precipitates in 95% yield with 56% conversion of **1** (Table 2, Run 2). The structure of the adduct is identified as shown in Eq. 2, because the characteristic N–H bands found in **1** were also observed in the IR and NMR spectra of **3** (Me, Ph_2).



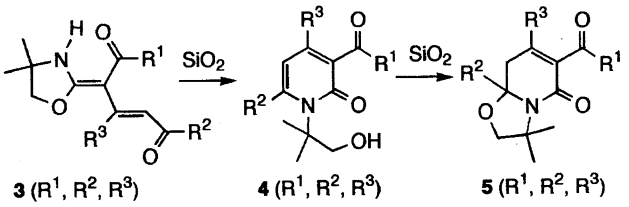
(2)

Interestingly, **3** (Me, Ph_2) was smoothly isomerized to 3-acetyl-1-(2-hydroxy-1,1-dimethylethyl)-4,6-diphenyl-2-pyridone (**4** (Me, Ph_2)) in 84% yield by adsorption on silica gel at r.t. for 6 h (Table 1). The IR and ^{1}H NMR spectra of **4** showed that the compounds were primary alcohols. The structure of **4** was confirmed by an easy conversion of **4** to the known *N*-dealkylated 3-acyl-2-pyridone **10**[13] (vide infra). A prolonged treatment of **3** (Me, Ph_2) with silica gel for 2 d afforded an isomeric product **5** (Me, Ph_2) as a major product (84%) and **4** (Me, Ph_2) as a minor one (4%). This fact indicates that 2-oxazoline **3** was isomerized to 2-pyridone **4**, which was then converted to **5** by silica gel (Eq. 3 and Table 1). Ammonia also catalyzed the ring transformation of **3** to **5** under ethanol-reflux conditions. The linear adduct did not cyclize to the pyridone by a treatment of acetic acid, which was sometimes a good catalyst in such cyclizations. The structure of **5** was determined as follows. Elemental analyses indicated **5** to be an isomer of **4**. It was obvious that **5** is not an alcohol from the IR spectra. The ^{1}H NMR spectra showed that two methylene moieties and a pair of methyl groups were diasteotopic, indicating that the molecule was chiral. A characteristic quaternary carbon peak was found at 90—95 ppm in the ^{13}C NMR spectra, suggesting the presence of a ketal moiety in **5**. From these data, **5** was assigned to be 4,6-disubstituted 3-acyl-7-oxa-1-azabicyclo[4.3.0]non-3-en-2-one, which had been formed by an intramolecular Michael addition of **4**.

Table 1. Ring Transformation of the 2-Oxazoline **3** to the 2-Pyridone Derivatives **4**, **5**, and **6**

Substrate	Reaction conditions			Products/%		
				4	**5**	**6**
3 (Me, Ph, Ph)	SiO_2	r.t.	6 h	84	4	0
3 (Me, Ph, Ph)	SiO_2	r.t.	2 d	4	84	0
3 (Me, Ph, Ph)	NH_3	78 °C	6 h	0	92[a)]	8[a)]
3 (Ph, Ph, H)	SiO_2	r.t.	2 d	0	38[a)]	49[a)]

a) Isolated as mixtures of **5** and **6**.



(3)

Usually, the pyridone derivatives, **4** and **5**, were directly obtained by the reaction of **1** with **2** and the subsequent treatment with silica gel without isolation of the linear adduct **3**. The results of the addition reactions are summarized in Table 2.

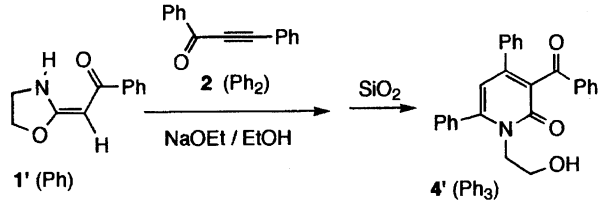
Similarly, 2-phenacyl-2-oxazoline **1′** (Ph),[7] which was the 4,4-demethylated derivative of **1** (Ph), was also reacted with diphenylpropynone to give the corresponding 3-benzoyl-2-pyridone derivative **4′** (Ph_3) after silica gel purification (Eq. 4). Interestingly, the pyridone **4′** (Ph_3) was so stable that it could not be converted to the corresponding dihydro-

Table 2. Michael Addition of 2-Acylmethyl-2-oxazoline with Acetylenic Ketones

Run	Substrate **1**	Reagent **2**		Conditions[a)]	Conversion of **1**	Yields of Products/%				
	R^1	R^2	R^3		%	**3**	**4**	**5**	**7**	Others
1	Me	Ph	Ph	A	78	0	41	16	14	—
2	Me	Ph	Ph	B	56	95	0	0	0	—
3	Me	Ph	Ph	C	78	0	68	0	0	—
4	Et	Ph	Ph	A	64	0	0	0	64	—
5	Et	Ph	Ph	B	82	0	10	0	54	—
6	Et	Ph	Ph	C	66	0	53	3	0	10[b)]
7	*i*-Pr	Ph	Ph	D	100	23	48	0	—	10[c)]
8	Bu	Ph	Ph	A	72	0	0	0	98	—
9	*t*-Bu	Ph	Ph	A	59	0	0	92	—	—
10	*t*-Bu	2-Furyl	Ph	A	72	0	0	80	—	—
11	Ph	Ph	Ph	A	78	0	80	7	—	—
12	Ph	*t*-Bu	Ph	E	68	29	0	0	—	69[d)]
13	2-Furyl	*t*-Bu	Ph	A	38	89	0	0	—	—
14	Ph	Ph	Bu	A	51	0	59	16	—	—
15	Ph	Ph	H	A	99	71	0	20[e)]	—	—
16	Ph	Me	H	A	77	74	0	0	—	—

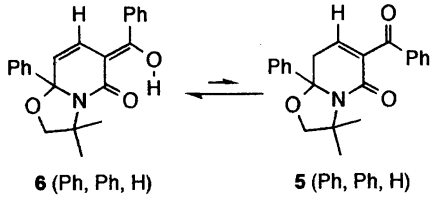
a) Reaction condition A: 1.1 molar amount of NaOEt in EtOH at r.t. for 5 h; B: 0.2 molar amount of NaOEt in EtOH at 0 °C for 2 d; C: 1.1 molar amount of LiH in MeCN at r.t. for 7 h; D: 1.1 molar amount of NaH and 15 molar amount of *i*-PrOH in toluene; E: 1.1 molar amount of NaOEt in EtOH at reflux for 1 h. b) **13**: A rearranged isomer of **5**. c) **14**: A rearranged isomer of **4**. d) **9′** (*t*-Bu, Ph): A deacylated linear adduct. e) **6**: An enol isomer of **5**.

pyridone derivative **5′** by the silica gel treatment. These results show that the main driving force of the ring transformation of 2-oxazolines **3** or **3′** to 2-pyridones **4** or **4′** is aromatization, and also indicate that the intramolecular cyclization of **4** to **5** is promoted by the reduction of a steric repulsion around the bulky 2-hydroxy-1,1-dimethylethyl group in **4**.



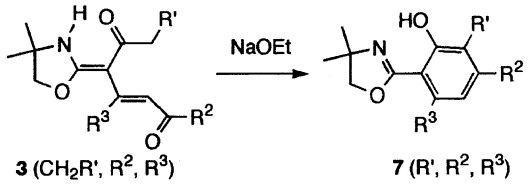
(4)

In the case of the reaction of a pivaloylacetylene (Table 2, Runs 12 and 13), only the linear adduct **3** (R^2=*t*-Bu) was yielded even after a silica gel treatment and the corresponding pyridone derivative, **4** or **5**, was not obtained at all. The fact is attributed to a steric hindrance of the pivaloyl carbonyl group in **3**. Acetylenic ketones in which R^3 were hydrogen were also apt to mainly give the linear adducts **3** (Runs 15 and 16). In this case, the adduct cyclized to **6** (Ph, Ph, H) upon a longer treatment with silica gel (Table 1). The compound was in equilibrium with its keto tautomer **5** in a deuteriochloroform solution (Eq. 5).



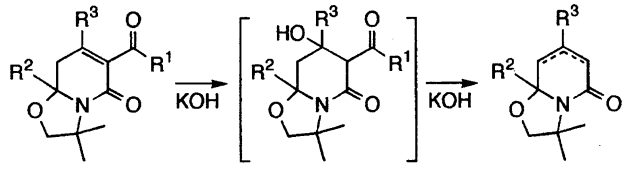
(5)

As a Michael donor, 2-acylmethyl-2-oxazolines (**1**) are less reactive than the corresponding β-keto esters or malonic esters, because the latter reacts with acetylenic ketones or esters more quickly.[21] In order to accelerate the addition, an equimolar amount of sodium ethoxide was used (condition A). Condition A provided good yields of adducts **3**—**5** unless the oxazoline acyl substituent R^1 was the primary alkyl group. When R^1 was primary (CH_2R'), salicylic acid derivatives **7** (R′, R^2, R^3) were yielded as the main or sole product under condition A (Runs 1,4, and 8) (Eq. 6). The compounds are formed in situ by an intramolecular aldol condensation of the initial Michael adducts **3** prior to the ring transformation of **3** to **4** (Eq. 3). We found good conditions in which **1** (CH_2R') gave the 2-pyridone derivative **4** selectively by using lithium hydride as a base in acetonitrile (condition C). Less basic lithium salts of **3** or **1** suppress the intramolecular aldol condensation. Although the addition of **1** with **2** proceeds more smoothly in acetonitrile or toluene than in ethanol, some undesirable by-products were often yielded in such aprotic solvents (Runs 6 and 7). A limited amount of isopropyl alcohol was added to toluene (condition D) in order to suppress the formation of by-products.[22]

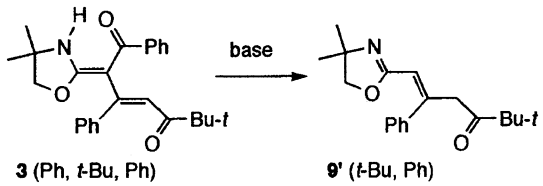


(6)

The conversion of 3-acyl-2-pyridone **4** to 5,6-dihydro-2-pyridone derivative **5** also proceeded by a treatment with sodium ethoxide at r.t. (Table 3). When **4** or **5** was reacted with potassium hydroxide at reflux in ethanol, deacylated product **9** was obtained in good yields. On the contrary, neither 3-acyl-*N*-(2-hydroxyethyl)-2-pyridones **4′** (Ph_3) nor *N*-unsubstituted **10** (vide infra) underwent such deacylation under similar conditions. The results indicate that the deacylation of **4** or **5** proceeds via a β-keto amide intermediate **8** (Eq. 7). The reaction of **5** in which R^1 were *t*-butyl with potassium hydroxide retarded such a deacylation but mainly gave *N*-dealkylated products **10** (Table 3). The unusual results suggest not only that the large pivaloyl group obstructs a nucleophilic attack of the hydroxide ion, but also that the C–N bond between the pyridone nitrogen and the bulky *N*-alkyl group is weakened by a steric repulsion. It is obvious that both **5** and **9** have a similar fused 2-pyridone skeleton by a comparison of their ^{1}H and ^{13}C NMR spectra, although the position of the carbon–carbon double bond of **9** is ambiguous. The reaction of the sodium salt of **1** (Ph) with **2** (*t*-Bu, Ph) at reflux gave mainly a linear deacylated product **9′** (*t*-Bu, Ph), and the yield of the expected adduct **3** (Ph, *t*-Bu, Ph) was low (Table 2, Run 12) due to deacylation under the basic conditions (Eq. 8 and Table 3).



(7)



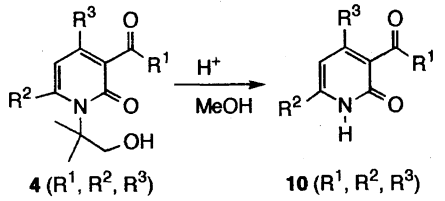
(8)

N-Dealkylation of 3-acyl-2-pyridone **4** was efficiently achieved by heating it with hydrochloric acid in ethanol at reflux for 1 h (Eq. 9 and Table 3). The yields of *N*-dealkylated 3-acetyl-2-pyridone (**10**) were excellent (>90%), while **4′** (Ph_3) did not give the expected *N*-dealkylated product at all even under vigorous conditions. Usually *N*-dealkylation of 2-pyridones are difficult except for *N*-methyl-2-pyridones,

Table 3. Transformations of 2-Pyridone Derivatives

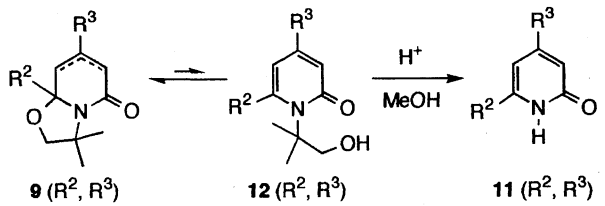
Substrate	Conditions				Conversion	Products (Yields/%)
	Reagent	Solvent	Temp	Time	%	
4 (Ph, Ph, Ph)	SiO_2	—	r.t.	48 h	100	**5** (Ph, Ph, Ph) (97)
4 (Ph, Ph, Ph)	NaOEt	EtOH	r.t.	1 h	100	**5** (Ph, Ph, Ph) (quantitative)
4 (Ph, Ph, Ph)	KOH	EtOH	Reflux	6 h	100	**9** (Ph, Ph) (96)
4 (Ph, Ph, Bu)	KOH	EtOH	Reflux	6 h	100	**9** (Ph, Bu) (97)
4 (Me, Ph, Ph)	KOH	EtOH	Reflux	6 h	100	**9** (Ph, Ph) (92)
4 (Et, Ph, Ph)	KOH	EtOH	Reflux	6 h	100	**9** (Ph, Ph) (94)
4 (*i*-Pr, Ph, Ph)	KOH	EtOH	Reflux	6 h	100	**9** (Ph, Ph) (95)
5 (Ph, Ph, Ph)	KOH	EtOH	Reflux	6 h	100	**9** (Ph, Ph) (94)
5 (*t*-Bu, Ph, Ph)	KOH	EtOH	Reflux	6 h	73	**10** (*t*-Bu, Ph, Ph) (50) and **9** (Ph, Ph) (38)
5 (*t*-Bu, 2-furyl, Ph)	KOH	EtOH	Reflux	6 h	85	**10** (*t*-Bu, 2-furyl, Ph) (86)
3 (Ph, *t*-Bu, Ph)	KOH	EtOH	Reflux	3 h	100	**9′** (*t*-Bu, Ph) (80)
3 (2-furyl, *t*-Bu, Ph)	KOH	EtOH	Reflux	4 h	100	**9′** (*t*-Bu, Ph) (94)
4 (Ph, Ph, Ph)	concd-HCl	MeOH	Reflux	1 h	100	**10** (Ph, Ph, Ph) (93)
4′ (Ph, Ph, Ph)	concd-HCl	MeOH	Reflux	3 h	0	No reaction
4 (Ph, Ph, Bu)	concd-HCl	EtOH	Reflux	1 h	100	**10** (Ph, Ph, Bu) (94)
4 (Me, Ph, Ph)	concd-HCl	EtOH	Reflux	1 h	100	**10** (Me, Ph, Ph) (87)
4 (Et, Ph, Ph)	concd-HCl	EtOH	Reflux	1 h	100	**10** (Et, Ph, Ph) (92)
4 (*i*-Pr, Ph, Ph)	concd-HCl	EtOH	Reflux	1 h	100	**10** (*i*-Pr, Ph, Ph) (95)
4 (*t*-Bu, Ph, Ph)	concd-HCl	EtOH	Reflux	1 h	100	**10** (*t*-Bu, Ph, Ph) (95)
5 (Ph, Ph, Ph)	concd-H_2SO_4	EtOH	Reflux	24 h	100	**10** (Ph, Ph, Ph) (93)
5 (Me, Ph, Ph)	concd-H_2SO_4	EtOH	Reflux	24 h	100	**10** (Me, Ph, Ph) (quantitative)
9 (Ph, Ph)	concd-H_2SO_4	EtOH	Reflux	24 h	100	**11** (Ph, Ph) (96)

which can be dealkylated by strong halogenation reagents such as PCl_5 or BBr_3 via the S_N2 mechanism.[24] On the contrary, the easy dealkylation of **4** should proceed via the S_N1 mechanism because the leaving alkyl group is tertiary and the reaction conditions are typical of solvolysis. The structure of **10** (Ph_3) was identified by a comparison with its authentic sample, which was prepared by a reported method.[13]

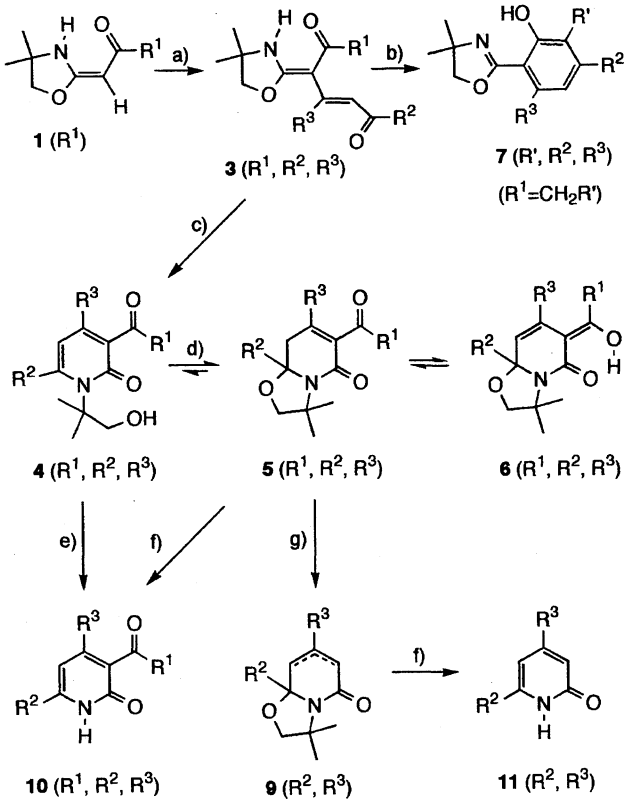


(9)

A similar treatment of the dihydropyridone derivatives, **5** and **9**, with sulfuric acid also gave *N*-dealkylated products, **10** and **11** (Eq. 10 and Table 3), though they were more sluggish than **4**. The lower rate of the reaction of **5** is accounted for by the fact that **5** is thermodynamically more stable than **4**, as shown in Eq. 3. The dealkylation of these dihydropyridones, **5** and **9**, may proceed via more unstable 1-(2-hydroxy-1,1-dimethylethyl)-2-pyridones, **4** and **12** (Eq. 10).



(10)



Scheme 1. Transformations of 2- Pyridones. a) NaOEt/EtOH and $R^2COC{\equiv}CR^3$; b) NaOEt; c) SiO_2; d) SiO_2 or NaOEt, r.t.; e) concd-HCl/EtOH, reflux, 1 h; h) concd-H_2SO_4, reflux, 6 h; g) KOH or NaOEt/EtOH, reflux.

Many methods of *N*- or *O*-alkylations of 1-unsubstituted 2-pyridones have been investigated.[25] The literature shows that the selectivity of *N*- or *O*-alkylation of 2-pyridones depends on both the reaction conditions and the substitutents on the ring. In order to demonstrate the possibility of *N*-alkylations of 6-substituted 3-acyl-2-pyridones, **10** (Ph_3) was treated with methyl iodide to give only an *N*-methylated product. *O*-Methylation of **10** (Ph_3) by dimethyl sulfate had been reported.[13] Thus, these *N*-unsubstituted 2-pyridones are useful starting material to *N*-functionalized-2-pyridones and 2-alkoxypyridines.

In conclusion, 3-acyl-1-(2-hydroxyethyl)-2-pyridone derivatives (**4** and **4′**) were obtained by a Michael addition of 2-acylmethyl-2-oxazolines (**1** and **1′**) with α,β-acetylenic ketones **2**, followed by a silica gel treatment. The *N*-*t*-alkyl substituent of **4** plays critical roles in the transformations of **4** to the other pyridone derivatives **5**,**9**,**10**, and **11** as summarized in Scheme 1.

Experimental

General. The melting points were measured on a Yanako micro-melting point apparatus, and were uncorrected. IR spectra were obtained with a JEOL JIR-Diamond 20 FT-IR spectrophotometer. All NMR spectra were recorded in chloroform-*d* using TMS as an internal standard at 400 MHz (^{1}H NMR) and 100 MHz (^{13}C NMR) on a Bruker DPX 400 or at 60 MHz (^{1}H NMR) on a JEOL PMX60SI spectrometer if mentioned. EI mass spectra were recorded on a JEOL JMS-AX505HA. Elemental microanalyses were performed using a Yanako MT-3 CHN corder. Column chromatography was conducted on silica gel (Wakogel C-200), available from Wako Pure Chemical Industries. Solvents were dried and distilled shortly before use.

Preparation of 2-Acylmethyl-2-oxazoline (1) from Acid Chloride.[7] The reagent was prepared by the following modified method. Benzoyl chloride (14.2 g, 100 mmol) was added to a solution of 2,4,4-trimethyl-2-oxazoline[26] (5.65 g, 50 mmol) and triethylamine 12.7 g, 125 mmol) in acetonitrile (200 ml) at r.t. with stirring. The mixture was refluxed for 3 h, and the solvent was removed by a rotary evaporator. To the residue, 100 ml of water was added and products were extracted with toluene. The organic layer was washed with 5% aqueous sodium carbonate and water, and dried over anhydrous sodium sulfate. The solvent was removed and the residue was dissolved in 100 ml of 1 mol dm^{-3} methanolic potassium hydroxide. The mixture was allowed to stand at r.t. for 12 h, the solvent was removed and 100 ml of water was added. It was extracted with toluene and the organic layer was washed with water and the dried over anhydrous sodium sulfate. The solvent was removed by a rotary evaporator and the residue was recrystallized from touene–hexane to give 8.68 g (90%) of 4,4-dimethyl-2-phenacyl-2-oxazoline (**1** (Ph)). Mp 100.5—101 °C. IR (KBr) 3230, 3072, 3059, 2976, 1626, 1581, 1541, 1508, 1466, 1443, 1394, 1369, 1321, 1219, 1167, 999, 858, 739, 696, 654 cm^{-1}. ^{1}H NMR δ=1.45 (6H, s), 4.16 (2H, s), 5.58 (1H, s), 7.20—7.45 (3H, m), 7.83 (2H, m), 9.8—10.0 (1H, broad). ^{13}C NMR δ=27.2 (q), 58.6 (s), 74.0 (d), 79.0 (t), 125.9 (d), 126.8 (d), 128.1 (d), 130.6 (d), 140.0 (s), 169.6 (s), 187.5 (s).

Preparation of 1 from Acid Anhydride.[8] A mixture of 2,4,4-trimethyl-2-oxazoline (20 mmol) and triethylamine (160 mmol) was added to a solution of aluminum chloride (30 mmol) in acetonitrile (40 ml). Acid anhydride (60 mmol) was added to the mixture below 0 °C during 30 min with stirring. The mixture was kept either at 0 °C for 6 h (acetic anhydride) or at 50 °C for 3 h (other alkanoic anhydrides). The reaction was quenched by adding 3 mol dm^{-3} aqueous sodium hydroxide (60 ml) at 0 °C and the products were extracted with toluene. The solvent was removed and the residue was dissolved in 1.5 mol dm^{-3} methanolic potassium hydroxide. A crude product was co-distilled with ethylene glycol (20 ml) under reduced pressure and recrystallized from benzene-hexane. The following compounds were obtained.

2-Acetonyl-4,4-dimethyl-2-oxazoline (1 (Me)):[1] Yield 71%. Mp 125—127 °C. IR (KBr) 3259, 2980, 1630, 1558, 1389, 1313, 1207, 1163, 1030, 717, 690 cm^{-1}; ^{1}H NMR (enamine/imine ratio=1/0.09), an enamine isomer δ=1.40 (6H, s), 2.02 (3H, s), 4.08 (2H, s), 4.87 (1H, s), 8.5—10 (1H, broad), an imine isomer δ=1.30 (6H, s), 2.25 (3H, s), 3.38 (2H, s), 3.99 (2H, s); ^{13}C NMR an enamine isomer δ=26.9 (q), 28.6 (q), 58.2 (s), 76.7 (d), 78.6 (t), 168.2 (s), 194.0 (s); an imine isomer δ=28.1 (q), 29.4 (q), 43.5 (t), 67.3 (s), 79.4 (t), 159.7 (s), 201.4 (s). Found: C, 62.15; H, 8.54; N, 9.16%. Calcd for $C_8H_{13}NO_2$: C, 61.91; H, 8.44; N, 9.03%.

1 (Et): Yield 56%. Mp 95—98 °C (colorless prisms from hexane); IR (Nujol®) 3260, 1630, 1554, 1495, 1320, 1297, 1204, 1172, 1160, 1015, 972, 730, 690 cm^{-1}; ^{1}H NMR (enamine/imine ratio=1/0.13), an enamine isomer δ=1.10 (3H, t, J=7.6 Hz), 1.40 (6H, s), 2.27 (2H, q, J=7.6 Hz), 4.08 (2H, s), 4.88 (1H, s), 7.8—9.9 (1H, broad), an imine isomer δ=1.17 (3H, t, J=7.3 Hz), 1.30 (6H, s), 2.56 (2H, q, J=7.3 Hz), 3.38 (2H, s), 3.98 (2H, s); ^{13}C NMR an enamine isomer δ=10.2 (q), 27.0 (q), 34.7 (t), 58.3 (s), 75.6 (d), 78.7 (t), 168.5 (s), 198.1 (s); an imine isomer δ=7.5 (q), 28.3 (q), 35.6 (t), 42.5 (t), 67.4 (s), 79.5 (t), 160.0 (s), 204.3 (s). Found: C, 63.76; H, 8.92; N, 8.15%. Calcd for $C_9H_{15}NO_2$: C, 63.88; H, 8.93; N, 8.28%.

1 (*i*-Pr): Yield 31%. Mp 96—97.5 °C (colorless prisms from hexane); IR (Nujol®) 3275, 1632, 1550, 1486, 1309, 1210, 1173, 1008, 995, 979, 771 cm^{-1}; ^{1}H NMR (enamine/imine ratio=1/0.09), an enamine isomer δ=1.09 (6H, d, J=6.8 Hz), 1.39 (6H, s), 2.44 (1H, septet, J=6.8 Hz), 4.08 (2H, s), 4.89 (1H, s), 9—10 (1H, broad), an imine isomer δ=1.14 (6H, d, J=6.9 Hz), 1.30 (6H, s), 2.74 (1H, septet, J=6.9 Hz), 3.44 (2H, s), 3.97 (2H, s); ^{13}C NMR an enamine isomer δ=19.7 (q), 26.9 (q), 39.3 (d), 58.1 (s), 74.2 (d), 78.5 (t), 168.7 (s), 201.3 (s); an imine isomer δ=17.9 (q), 28.1 (q), 40.4 (t), 40.5 (d), 67.2 (s), 79.3 (t), 159.9 (s), 207.2 (s). Found: C, 65.62; H, 9.39; N, 7.78%. Calcd for $C_{10}H_{17}NO_2$: C, 65.54; H, 9.53; N, 7.63%.

1 (Bu): Yield 64%. Mp 64—66 °C (colorless prisms from hexane); IR (Nujol®) 3260, 1630, 1550, 1488, 1320, 1212, 1202, 1170, 1159, 1160, 1012, 976, 733, 694 cm^{-1}; ^{1}H NMR (enamine/imine ratio=1/0.12), an enamine isomer δ=0.91 (3H, t, J=7.5 Hz), 1.34 (2H, sextet, J=7.5 Hz), 1.39 (6H, s), 1.57 (2H, quintet, J=7.6 Hz), 2.25 (2H, t, J=7.6 Hz), 4.07 (2H, s), 4.88 (1H, s), 7.8—9.5 (1H, broad); an imine isomer δ=0.91 (3H, t, J=7.5 Hz), 1.30 (6H, s), 1.34 (2H, sextet, J=7.5 Hz), 1.57 (2H, quintet, J=7.6 Hz), 2.52 (2H, t, J=7.6 Hz), 3.37 (2H, s), 3.98 (1H, s); ^{13}C NMR an enamine isomer δ=14.0 (q), 22.6 (t), 27.1 (q), 28.4 (t), 41.7 (t), 58.3 (s), 76.3 (d), 78.7 (t), 168.5 (s), 197.7 (s); an imine isomer δ=13.8 (q), 22.2 (t), 25.6 (t), 28.3 (q), 42.1 (t), 42.8 (t), 67.4 (s), 79.5 (t), 160.1 (s), 203.9 (s). Found: C, 66.96; H, 9.89; N, 7.10%. Calcd for $C_{11}H_{19}NO_2$: C, 66.97; H, 9.71; N, 7.10%.

Addition of 1 with 2 under Condition A. Sodium ethoxide (1.20 mmol in 2.4 ml of ethanol) was added to a solution of **1** (Me) (0.16 g, 1.03 mmol) in ethanol (4.6 ml) and the solution was stirred for 5 min. A solution of diphenylpropynone (0.25 g, 1.21 mmol) in ethanol (3 ml) was added to the mixture with stirring. The solution

turned to deep red. After 5 h, water (50 ml) and toluene (50 ml) were added to the mixture. The yellow organic layer was washed with brine and dried over sodium sulfate. Crude products were separated by silica gel column chromatography. The first toluene eluate gave 48 mg (14%) of 2-(2-hydroxy-4,6-diphenylphenyl)-4,4-dimethyl-2-oxazoline (**7** (H, Ph, Ph)). Mp 139—141 °C (colorless needles from toluene–hexane); IR (KBr) 3056, 2966, 1616, 1558, 1396, 1356, 1211, 1086, 1051, 762, 700 cm^{-1}; ^1H NMR δ=1.35 (6H, s), 3.73 (2H, s), 7.02 (1H, d, J=1.8 Hz), 7.28 (1H, d, J=1.8 Hz), 7.32—7.45 (8H, m), 7.63—7.65 (2H, m), 12.97 (1H, broad s); ^{13}C NMR δ=28.3 (q), 65.9 (s), 78.1 (t), 108.2 (s), 114.2 (d), 120.9 (d), 126.9 (d), 127.2 (d), 127.4 (d), 128.1 (d), 128.6 (d), 128.8 (d), 139.9 (s), 142.6 (s), 143.8 (s), 144.5 (s), 160.9 (s), 164.6 (s). Found: C, 80.72; H, 6.22; N, 4.04%. Calcd for $C_{23}H_{21}NO_2$: C, 80.44; H, 6.16; N, 4.08%. The second toluene eluate gave 0.10 g of a pale yellow oil, which was identified as an ethanol adduct of the acetylene based on the ^1H NMR spectrum. The third toluene eluate was 58 mg (16%) of the dihydropyridone derivative **5** (Me, Ph, Ph). Mp 76—78 °C (colorless needles from hexane); IR (KBr) 3059, 2970, 2875, 1705, 1647, 1595, 1446, 1408, 1277, 1194, 1045, 1028, 1012, 761, 702 cm^{-1}; ^1H NMR δ=1.54 (3H, s), 1.67 (3H, s), 2.10 (3H, s), 3.05 (1H, d, J=16.0 Hz), 3.37 (1H, d, J=8.8 Hz), 3.47 (1H, d, J=16.0 Hz), 3.80 (1H, d, J=8.8 Hz), 6.92—6.94 (2H, m), 7.23—7.51 (8H, m); ^{13}C NMR δ=23.1 (q), 25.2 (q), 31.6 (q), 44.8 (t), 61.2 (s), 76.7 (t), 95.1 (s), 126.2 (d), 126.7 (d), 128.4 (d), 128.6 (d), 128.7 (d), 129.2 (d), 136.0 (s), 137.5 (s), 140.4 (s), 142.9 (s), 160.9 (s), 202.0 (s). Found: C, 76.62; H, 6.33; N, 3.75%. Calcd for $C_{23}H_{23}NO_3$: C, 76.43; H, 6.41; N, 3.88%. In the deuteriochloroform solution of **5** (Me, Ph, Ph), **6** (Me, Ph, Ph) was observed as a minor tautomer: δ=1.36 (3H, s), 1.46 (3H, s), 1.61 (3H, s), 3.46 (1H, d, J=8.7 Hz), 3.74 (1H, d, J=8.7 Hz), 5.68 (1H, s), 7.14 (5H, m), 7.28 (5H, m), 14.97 (1H, s). A toluene–ethyl acetate (4 : 1) eluate gave 34 mg (0.22 mmol) of the recovered substrate **1**. A toluene–ethyl acetate (1 : 1) eluate gave 148 mg (41%) of 3-acetyl-1-(2-hydroxy-1,1-dimethylethyl)-4,6-diphenyl-2-pyridone (**4** (Me, Ph, Ph)). Mp 81.5—82 °C (colorless needles from toluene–hexane); IR (KBr) 3385 (br), 1699, 1635, 1539, 1489, 1363, 1072, 785, 768, 702, 679 cm^{-1}; ^1H NMR δ=1.37 (6H, s), 2.33 (3H, s), 3.87 (2H, d, J=5.6 Hz), 5.12 (1H, t, J=5.6 Hz), 6.18 (1H, s), 7.34—7.44 (10H, m); ^{13}C NMR δ=28.1 (q), 31.7 (q), 70.5 (s), 72.0 (t), 114.9 (d), 128.0 (t), 128.1 (d), 128.5 (d), 128.8 (d), 129.1 (d), 129.3 (d), 130.3 (s), 136.5 (s), 139.5 (s), 147.8 (s), 150.8 (s), 166.2 (s), 202.4 (s). Found: C, 76.70; H, 6.68; N, 3.92%. Calcd for $C_{23}H_{23}NO_3$: C, 76.43; H, 6.41; N, 3.88%.

Similarly following compounds were identified.

3 (2-furyl, *t*-Bu, Ph): Mp 145—146 °C (yellow needles from chloroform–hexane); IR (KBr) 3238, 3111, 2970, 1674, 1610, 1583, 1566, 1520, 1477, 1354, 1068, 1014, 985, 881, 791, 700 cm^{-1}; ^1H NMR δ=1.12 (9H, s), 1.44 (3H, s), 1.51 (3H, s), 3.99 (1H, d, J=8.2 Hz), 4.07 (1H, d, J=8.2 Hz), 6.19 (1H, dd, J=3.4 and 1.6 Hz), 6.71 (1H, d, J=3.4 Hz), 6.96 (1H, s), 7.22 (1H, d, J=1.6 Hz), 7.26—7.32 (3H, m), 7.54—7.56 (2H, m), 10.63 (1H, br); ^{13}C NMR δ=26.7 (q), 27.0 (q), 27.1 (q), 44.0 (s), 58.9 (s), 78.8 (t), 88.7 (d), 110.9 (d), 114.1 (d), 122.5 (d), 127.6 (d), 128.3 (d), 128.8 (d), 142.7 (s), 143.3 (d), 148.0 (s), 153.4 (s), 168.3 (s), 176.5 (s), 204.0 (s). Found: C, 72.99; H, 6.89; N, 3.58%. Calcd for $C_{24}H_{27}NO_4$: C, 73.26; H, 6.92; N, 3.56%.

3 (Ph, Ph, H): Mp 167—168 °C (yellow needles from chloroform–hexane); IR (KBr) 3219, 3080, 3061, 2974, 2933, 1647, 1616, 1541, 1362, 1315, 1217, 1203, 1043, 1022, 978, 770, 700 cm^{-1}; ^1H NMR δ=1.54 (6H, s), 4.45 (2H, s), 7.01 (1H, d, J=15.4 Hz), 7.36—7.49 (8H, m), 7.81—7.83 (2H, m), 7.87 (1H, d, J=15.4 Hz), 11.17 (1H, broad); ^{13}C NMR δ=27.3 (q), 58.9 (s), 80.2 (t), 91.8 (s), 114.1 (d), 128.01 (d), 128.09 (d), 128.16 (d), 128.23 (d), 130.0 (d), 131.5 (d), 139.6 (s), 140.9 (s), 143.0 (d), 169.9 (s), 190.7 (s), 194.9 (s). Found: C, 75.96; H, 6.18; N, 3.78%. Calcd for $C_{22}H_{21}NO_3$: C, 76.06; H, 6.09; N, 4.03%.

3 (Ph, Me, H): Mp 146.5—148.5 °C (pale red needles from toluene–hexane); IR (KBr) 3207, 2978, 1670, 1614, 1543, 1437, 1356, 1300, 1176, 1107, 974, 962, 700 cm^{-1}; ^1H NMR δ=1.50 (6H, s), 2.04 (3H, s), 4.38 (2H, s), 6.35 (1H, d, J=16.1 Hz), 7.43—7.48 (5H, m), 7.48 (1H, d, J=16.1 Hz), 11.14 (1H, broad s); ^{13}C NMR δ=26.2 (q), 27.1 (q), 58.7 (s), 80.1 (t), 90.4 (s), 119.6 (d), 127.9 (d), 128.0 (d), 129.9 (d), 140.7 (s), 142.0 (d), 169.6 (s), 194.1 (s), 198.7 (s). Found: C, 71.41; H, 6.68; N, 4.89%; *m/z* 285.1348 (M^+). Calcd for $C_{17}H_{19}NO_3$: C, 71.56; H, 6.71; N, 4.91%; M, 285.1365.

4 (Ph, Ph, Ph): Mp 148—149 °C (pale yellow prisms from toluene–hexane); IR (KBr) 3466 (broad), 3064, 2987, 1682, 1620, 1537, 1491, 1365, 1261, 1155, 1063, 968, 764, 702 cm^{-1}; ^1H NMR δ=1.37 (6H, s), 3.86 (2H, d, J=5.7 Hz), 4.92 (1H, t, J=5.7 Hz), 6.29 (1H, s), 7.23—7.52 (13H, m), 7.87—7.89 (2H, m); ^{13}C NMR δ=28.0 (q), 70.3 (s), 71.7 (t), 114.9 (d), 128.0 (d), 128.1 (d), 128.2 (s), 128.5 (d), 128.6 (d×2), 129.06 (d), 129.14 (d), 129.16 (d), 133.4 (d), 136.2 (s), 137.1 (s), 139.7 (s), 148.9 (s), 151.0 (s), 166.5 (s), 195.1 (s). Found: C, 79.40; H, 6.02; N, 3.05%. Calcd for $C_{28}H_{25}NO_3$: C, 79.41; H, 5.95; N, 3.31%.

4 (Ph, Ph, Bu): Mp 125—125.5 °C (pale yellow needles from toluene–hexane); IR (KBr) 3464, 2956, 1668, 1624, 1576, 1549, 1446, 1267, 1055, 949, 704 cm^{-1}; ^1H NMR δ=0.82 (3H, t, J=7.3 Hz), 1.26 (2H, m), 1.50 (2H, m), 2.34 (2H, t, J=7.9 Hz), 3.80 (2H, d, J=4.3 Hz), 5.02 (1H, t, J=4.3 Hz), 6.08 (1H, s), 7.43 (5H, s), 7.47 (2H, t, J=7.5 Hz), 7.59 (1H, t, J=7.4 Hz), 7.92 (2H, d, J=7.4 Hz); ^{13}C NMR δ=13.7 (q), 22.7 (t), 28.0 (q), 31.5 (t), 32.1 (t), 70.1 (s), 71.9 (t), 115.2 (d), 128.1 (d), 128.5 (d), 128.7 (d), 128.9 (d), 129.1 (d), 133.6 (d), 137.2 (s), 139.8 (s), 150.7 (s), 151.9 (s), 166.5 (s), 195.6 (s). Found: C, 77.16; H, 7.48; N, 3.30%. Calcd for $C_{26}H_{29}NO_3$: C, 77.39; H, 7.24; N, 3.47%.

5 (Ph, Ph, Ph): Mp 188—189 °C (colorless needles from toluene–hexane); IR (KBr) 2980, 1672, 1647, 1621, 1597, 1498, 1408, 1275, 1240, 1012, 783, 770, 696, 667 cm^{-1}; ^1H NMR δ=1.53 (3H, s), 1.66 (3H, s), 3.24 (1H, d, J=15.5 Hz), 3.37 (1H, d, J=8.6 Hz), 3.54 (1H, d, J=15.5 Hz), 3.77 (1H, d, J=8.6 Hz), 6.9—7.8 (15H, m); ^{13}C NMR δ=23.1 (q), 25.4 (q), 44.9 (t), 61.4 (s), 76.7 (t), 95.3 (s), 126.6 (d), 127.0 (d), 128.3 (d), 128.41 (d), 128.44 (d), 128.9 (d), 129.0 (d), 129.3 (d), 133.2 (d), 133.6 (s), 136.7 (s), 137.4 (s), 140.7 (s), 144.0 (s), 161.1 (s), 195.0 (s). Found: C, 79.46; H, 5.87; N, 3.30%. Calcd for $C_{28}H_{25}NO_3$: C, 79.41; H, 5.95; N, 3.31%.

5 (*t*-Bu, Ph, Ph): Mp 118.5—119 °C (colorless needles from hexane); IR (KBr) 3064, 2974, 1697, 1645, 1448, 1398, 1277, 1045, 1012, 771, 762, 708 cm^{-1}; ^1H NMR δ=0.82 (9H, s), 1.57 (3H, s), 1.66 (3H, s), 3.14 (1H, d, J=16.2 Hz), 3.36 (1H, d, J=8.8 Hz), 3.39 (1H, d, J=16.2 Hz), 3.78 (1H, d, J=8.8 Hz), 6.93—6.95 (2H, m), 7.21—7.27 (3H, m), 7.37—7.44 (3H, m), 7.56—7.58 (2H, m); ^{13}C NMR δ=23.1 (q), 25.3 (q), 26.7 (q), 44.8 (s), 44.9 (t), 61.3 (s), 76.5 (t), 95.1 (s), 126.5 (d), 127.6 (d), 128.3 (d), 128.4 (d), 128.8 (d), 128.9 (d), 135.6 (s), 138.3 (s), 140.5 (s), 141.2 (s), 161.3 (s), 212.0 (s). Found: C, 77.30; H, 7.30; N, 3.60%. Calcd for $C_{26}H_{29}NO_3$: C, 77.39; H, 7.24; N, 3.47%.

5 (*t*-Bu, 2-furyl, Ph): Mp 207—208.5 °C (colorless needles from hexane); IR (KBr) 3143, 3122, 2972, 1697, 1637, 1396, 1284, 1043, 1012, 768, 758, 700 cm^{-1}; ^1H NMR δ=0.73 (9H, s), 1.62 (3H, s), 1.71 (3H, s), 3.09 (1H, d, J=16.5 Hz), 3.59 (1H, d, J=16.5 Hz), 3.70 (1H, d, J=8.8 Hz), 3.86 (1H, d, J=8.8 Hz), 6.42 (1H, dd, J=3.3 and 1.9 Hz), 6.51 (1H, d, J=3.3 Hz), 7.16—7.19 (2H,

m), 7.28—7.36 (3H, m), 7.51 (1H, d, J=1.9 Hz); ^{13}C NMR δ=23.4 (q), 25.3 (q), 26.3 (q), 41.4 (t), 44.9 (s), 61.2 (s), 76.7 (t), 90.8 (s), 110.3 (d), 110.4 (d), 128.3 (d), 128.4 (d), 129.0 (d), 135.3 (s), 138.0 (s), 142.1 (s), 143.3 (d), 152.0 (s), 160.7 (s), 210.5 (s). Found: C, 73.54; H, 7.00; N, 3.72%. Calcd for $C_{24}H_{27}NO_4$: C, 73.26; H, 6.92; N, 3.56%.

5 (Ph, Ph, Bu): Obtained in a mixture with recovered **1** (Ph). ^{1}H NMR (60 MHz) δ=0.53 (3H, t, J=8.0 Hz), 1.4 (4H, m), 1.45 (3H, s), 1.57 (3H, s), 1.83 (2H, t, J=8.0 Hz), 2.84 (1H, d, J=14.0 Hz), 3.03 (1H, d, J=14.0 Hz), 3.30 (1H, d, J=9.0 Hz), 3.70 (1H, d, J=9.0 Hz), 7.2—7.4 (8H, m), 7.7—7.9 (2H, m).

6 (Ph, Ph, H): Mp 166—167.5 °C (colorless needles from toluene–hexane); IR (KBr) 3066, 2997, 2881, 1637, 1591, 1560, 1431, 1340, 1014, 960, 916, 766, 698 cm^{-1}; ^{1}H NMR δ=1.47 (3H, s), 1.67 (3H, s), 3.55 (1H, d, J=8.7 Hz), 3.84 (1H, d, J=8.7 Hz), 5.63 (1H, d, J=9.9 Hz), 6.22 (1H, d, J=9.9 Hz), 7.3—7.5 (10H, m), 15.38 (1H, s); ^{13}C NMR δ=24.6 (q), 25.1 (q), 61.7 (s), 76.9 (t), 96.0 (s), 99.8 (s), 119.8 (d), 122.1 (d), 124.4 (d), 128.17 (d), 128.21 (d), 128.9 (d), 129.1 (d), 130.5 (d), 134.3 (s), 143.0 (s), 168.4 (s), 171.2 (s). Found: C, 76.08; H, 6.14; N, 3.96%. Calcd for $C_{22}H_{21}NO_3$: C, 76.06; H, 6.09; N, 4.03%. **5** (Ph, Ph, H) was found as a minor tautomer in the deuteriochloroform solution of **6** (Ph, Ph, H): ^{1}H NMR δ=1.55 (3H, s), 1.63 (3H, s), 3.06 (1H, dd, J=17.2 and 6.5 Hz), 3.13 (1H, dd, J=17.2 and 2.4 Hz), 3.34 (1H, d, J=8.9 Hz), 3.77 (1H, d, J=8.9 Hz), 6.54 (1H, dd, J=6.5 and 2.4 Hz), 7.3—7.6 (8H, m), 7.8—7.9 (2H, m).

7 (Me, Ph, Ph): Mp 153—154.5 °C (colorless prisms from hexane); IR (KBr) 3028, 2980, 1618, 1396, 1367, 1196, 1140, 1120, 1007, 976, 878, 779, 704 cm^{-1}; ^{1}H NMR δ=1.35 (6H, s), 2.25 (3H, s), 3.73 (2H, s), 6.73 (1H, s), 7.29—7.42 (10H, m), 13.25 (1H, br); ^{13}C NMR δ=13.5 (q), 28.3 (q), 65.8 (s), 78.1 (t), 107.3 (s), 122.6 (s), 123.2 (d), 126.7 (d), 127.2 (d), 127.4 (d), 128.1 (d), 128.6 (d), 129.1 (d), 140.1 (s), 141.2 (s), 142.6 (s), 145.4 (s), 159.1 (s), 165.1 (s). Found: C, 80.41; H, 6.44; N, 3.85%. Calcd for $C_{24}H_{23}NO_2$: C, 80.64; H, 6.49; N, 3.92%.

7 (Pr, Ph, Ph): Mp 150—151 °C (colorless prisms from hexane); IR (KBr) 3027, 2962, 1618, 1402, 1304, 1147, 1124, 766, 704 cm^{-1}; ^{1}H NMR δ=0.85 (3H, t, J=7.3 Hz), 1.35 (6H, s), 1.60 (2H, m), 2.62 (2H, m), 3.73 (2H, s), 6.68 (1H, s), 7.24—7.40 (10H, m), 13.1 (1H, broad); ^{13}C NMR δ=14.5 (q), 22.9 (t), 28.3 (q), 29.6 (t), 65.9 (s), 78.1 (t), 107.7 (s), 123.4 (d), 126.7 (d), 127.0 (d), 127.37 (d), 127.42 (s), 127.9 (s), 128.6 (d), 128.9 (d), 140.1 (s), 141.5 (s), 142.6 (s), 145.6 (s), 159.0 (s), 165.1 (s). Found: C, 80.91; H, 7.16; N, 3.60%. Calcd for $C_{26}H_{27}NO_2$: C, 81.01; H, 7.06; N, 3.63%.

Addition of 1 with 2 under Condition B. To a solution of **1** (Me) (0.16 g, 1.03 mmol) and sodium ethoxide (0.10 mmol) in ethanol (4 ml), a solution of diphenylpropynone (0.25 g, 1.21 mmol) in ethanol (4 ml) was added slowly (2 min) to the mixture. The solution turned to yellow-brown and was allowed to stand at 0 °C for 2 d. Red precipitates were separated and washed with ethanol, and then hexane, to give 0.20 g (0.55 mmol) of pure **3** (Me, Ph_2). To the filtrate, water (50 ml) and benzene (50 ml) was added and the organic layer was washed with brine to give 0.22 g of brown oil, which was treated by silica gel column chromatography. The first benzene eluate gave 0.13 g of ethanol-adduct of the acetylene. The second chloroform eluate gave 0.07 g (0.45 mmol) of the recovered substrate. The conversion of the substrate was 56%, and yield of the product **3** (Me, Ph, Ph) was 95%. Orange prisms; mp 177.5—179.5 °C; IR (KBr) 3226, 2978, 1645, 1616, 1539, 1435, 1363, 1219, 1051, 1012, 972, 768, 698 cm^{-1}; ^{1}H NMR δ=1.34 (3H, s), 1.37 (3H, s), 1.78 (3H, s), 3.92 (2H, s), 7.09 (1H, s), 7.36—7.45 (5H, m), 7.49 (1H, tt, J=7.3 and 1.4 Hz), 7.57—7.59 (2H, m), 7.89—7.91 (2H, m), 10.30 (1H, broad s); ^{13}C NMR δ=27.1 (q), 27.4 (q), 58.8 (s), 78.7 (t), 90.6 (s), 124.4 (d), 127.6 (d), 128.2 (d), 128.3 (d), 128.6 (d), 129.2 (d), 132.1 (d), 139.4 (s), 142.4 (s), 149.4 (s), 167.0 (s), 192.2 (s), 193.3 (s). Found: C, 76.55; H, 6.42; N, 4.08%. Calcd for $C_{23}H_{23}NO_3$: C, 76.43; H, 6.41; N, 3.88%.

Addition of 1 with 2 under Condition C. A mixture of **2** (Et) (0.34 g, 2.0 mmol), diphenylpropynone (0.46 g, 2.2 mmol), and granules of lithium hydride (20.2 mg, 2.54 mmol) in acetonitrile (20 ml) was stirred at r.t. for 7 h. After the usual work up, crude products was purified by column chromatography. The first toluene eluate gave the recovered acetylene (51 mg), and the second toluene eluate gave 50 mg (10%) of a rearranged isomer **13**, which was tentatively assigned as 5-benzoyl-6-ethyl-9,9-dimethyl-4-phenyl-7-oxa-1-azabicyclo[4.3.0]non-4-en-2-one:[22] Mp 158—159 °C (colorless needles from toluene–hexane); IR (KBr) 3064, 2970, 1653, 1595, 1416, 1396, 1311, 1271, 1063, 768, 743, 708, cm^{-1}; ^{1}H NMR (60 MHz) δ=1.12 (3H, t, J=7.2 Hz), 1.65 (6H, s), 2.1—2.4 (2H, m), 3.43 (2H, s), 3.82 (1H, d, J=9.0 Hz), 3.88 (1H, d, J=9.0 Hz), 6.9—7.3 (3H, m), 7.10 (5H, s), 7.5—7.7 (2H, m); ^{13}C NMR δ=8.7 (q), 25.1 (q), 25.2 (q), 32.4 (t), 41.1 (t), 60.8 (s), 77.7 (t), 98.7 (s), 128.1 (d), 128.2 (d), 128.5 (d), 128.8 (d), 129.3 (d), 133.0 (d), 135.1 (s), 137.1 (s), 137.3 (s), 137.7 (s), 165.9 (s), 196.3 (s). Found: C, 76.51; H, 6.70; N, 3.78%. Calcd for $C_{24}H_{25}NO_3$: C, 76.77; H, 6.71; N, 3.73%. An eluate of toluene–ethyl acetate (5 : 1) gave 110 mg (0.66 mmol) of recovered substrate **1** (Et). The next toluene–ethyl acetate (5 : 1) eluate gave 265 mg (53%) of **4** (Et, Ph, Ph). Mp 108—110 °C (colorless needles from toluene–hexane); IR (KBr) 3464, 2939, 1703, 1618, 1566, 1535, 1489, 1363, 1066, 773, 698 cm^{-1}; ^{1}H NMR δ=1.01 (3H, t, J=7.2 Hz), 1.37 (6H, s), 2.53 (2H, q, J=7.2 Hz), 3.86 (2H, d, J=5.6 Hz), 5.16 (1H, t, J=5.6 Hz), 6.18 (1H, d, J=0.7 Hz), 7.35—7.42 (5H, m), 7.42 (5H, s); ^{13}C NMR δ=7.7 (q), 28.0 (q), 37.4 (t), 70.5 (s), 72.0 (t), 114.8 (d), 128.0 (d), 128.1 (d), 128.5 (d), 128.7 (d), 129.1 (d), 129.3 (d), 130.5 (s), 136.4 (s), 139.6 (s), 147.2 (s), 150.6 (s), 166.2 (s), 205.6 (s). Found: C, 76.54; H, 6.76; N, 3.74%. Calcd for $C_{24}H_{25}NO_3$: C, 76.77; H, 6.71; N, 3.70%.

Addition of 1 with 2 under Condition D. In a flask was placed sodium hydride (60% in mineral oil, 0.09 g, 2.25 mmol), which was rinsed twice with toluene. A solution of **1** (*i*-Pr) (0.37 g, 2.02 mmol) in toluene (4 ml) was added to the flask and stirred for a few minutes in order to complete a metalation reaction. Isopropyl alcohol (1.82 g, 30.3 mmol) and then a solution of **2** (Ph_2) (0.52 g, 2.52 mmol) in toluene (4 ml) were added to the flask with stirring. The color of the solution turned pale yellow to red-brown immediately. After the solution was stirred for 2.5 h at r.t. (17 °C), cold water (150 ml) and toluene (50 ml) were added. The organic layer was washed with brine and dried over sodium sulfate. A crude red oil was purified by column chromatography. The first toluene eluate was 0.11 g of the recovered acetylene. The second toluene–dichloromethane (4 : 1) gave 0.18 g (0.46 mmol) of **3** (*i*-Pr, Ph_2). ^{1}H NMR (60 MHz) δ=0.68 (3H, d, J=8.0 Hz), 0.91 (3H, d, J=8.0 Hz), 1.33 (6H, s), 2.53 (1H, septet, J=8.0 Hz), 3.83 (2H, s), 7.11 (1H, s), 7.2—7.7 (8H, m), 7.8—8.0 (2H, m), 10.50 (1H, broad s). The compound was completely converted to **4** (*i*-Pr, Ph_2) during recrystallization from toluene–hexane. **4** (*i*-Pr, Ph_2): Mp 138—140 °C (colorless needles); IR (KBr) 3454, 3055, 3030, 2966, 1697, 1628, 1578, 1572, 1533, 1489, 1392, 1059, 993, 762, 702 cm^{-1}; ^{1}H NMR δ=0.97 (6H, d, J=7.0 Hz), 1.37 (6H, s), 2.55 (1H, septet, J=7.0 Hz), 3.86 (2H, d, J=5.6 Hz), 5.19 (1H, t, J=5.6 Hz), 6.17 (1H, s), 7.38 (5H, s), 7.42 (5H, s); ^{13}C NMR δ=17.7 (q), 28.0 (q), 41.7 (d), 70.4 (s), 72.0 (t), 114.9 (d), 128.0 (d), 128.2 (d), 128.5 (d), 128.7 (d), 129.0 (d), 129.3 (d), 130.1 (s), 136.7 (s), 139.7 (s),

147.3 (s), 150.6 (s), 166.3 (s), 208.4 (s). Found: C, 77.38; H, 7.09; N, 3.56%. Calcd for $C_{25}H_{27}NO_3$: C, 77.09; H, 6.99; N, 3.60%. The third toluene–ethyl acetate (20 : 1—1 : 1) eluate gave 0.46 g of a mixture (82 : 18 in molar ratio by ^{1}H NMR) of **4** (*i*-Pr, Ph_2) and **14** (*i*-Pr, Ph_2), which was tentatively assigned as 1-(2-hydroxy-1,1-dimethylethyl)-5-isobutyryl-4,6-diphenyl-2-pyridone.[22] Spectra of **14** (*i*-Pr, Ph_2): ^{1}H NMR δ=0.25 (6H, d, J=6.9 Hz), 1.31 (6H, s), 1.65 (1H, septet, J=6.9 Hz), 3.77 (2H, d, J=5.1 Hz), 5.65 (1H, t, J=5.1 Hz), 6.61 (1H, s), 7.34—7.43 (10H, m).

Addition of 1 with 2 under Condition E. A solution of sodium salt of **1** (Ph) (1 mmol), 4,4-dimethyl-1-phenyl-1-pentyn-3-one (1.5 mmol) in ethanol (10 ml) was refluxed for 1 h. After the usual work up, the mixture was treated by chromatography. The first toluene eluate was an ethanol adduct of the acetylene. The second eluate (toluene–chloroform 5 : 1—2 : 1) gave a mixture of **1** (Ph) (0.32 mmol) and 4,4-dimethyl-2-(5,5-dimethyl-4-oxo-2-phenyl-1-hexenyl)-2-oxazoline (a deacylated product **9′**, 0.47 mmol). The structure of the latter compound was identified by comparing it with the ^{1}H NMR spectrum of an authentic sample (vide infra). The third eluate (toluene–ethyl acetate 20 : 1—10 : 1) gave **3** (Ph, *t*-Bu, Ph) (81 mg, 29%). Yellow needles from toluene–hexane; mp 159.5—160.5 °C; IR (KBr) 3228, 2966, 1672, 1614, 1578, 1529, 1431, 1356, 1070, 978, 760, 696 cm^{-1}; ^{1}H NMR δ=1.01 (9H, s), 1.46 (3H, s), 1.52 (3H, s), 3.98 (1H, d, J=8.2 Hz), 4.05 (1H, d, J=8.2 Hz), 6.59 (1H, s), 7.04 (2H, t, J=7.3 Hz), 7.21 (1H, t, J=7.3 Hz), 7.18—7.24 (3H, m), 7.25—7.26 (2H, m), 7.33—7.38 (2H, m), 10.59 (1H, broad s); ^{13}C NMR δ=26.5 (q), 27.0 (q), 27.2 (q), 43.8 (s), 58.9 (s), 78.9 (t), 90.6 (s), 120.8 (d), 127.1 (d), 127.5 (d), 127.9 (d), 128.0 (d), 128.6 (d), 128.8 (d), 142.1 (s), 143.5 (s), 150.4 (s), 168.1 (s), 191.6 (s), 203.7 (s). Found: C, 76.71; H, 7.23; N, 3.59%. Calcd for $C_{26}H_{29}NO_3 \cdot 0.25\,H_2O$: C, 76.54; H, 7.29; N, 3.43%.

Conversion of 3 to 4 by Silica Gel. The linear Michael adduct, **3** (Me, Ph_2) (0.18 g, 0.50 mmol) was dissolved in 2 ml of chloroform, adsorbed on silica gel column and allowed to stand at r.t. for 12 h. The first benzene eluate gave 10 mg (0.03 mmol, 6%) of **5** (Me, Ph_2). The second eluate (benzene–ethyl acetate 1 : 1) gave 0.15 g (0.42 mmol, 84%) of **4** (Me, Ph_2).

Conversion of 3 to 5 by Ammonia. The linear Michael adduct, **3** (Me, Ph_2) (0.18 g, 0.50 mmol) was dissolved in 5 ml of 0.5 mol dm^{-3} ethanolic ammonia solution and refluxed for 6 h. Water (40 ml) was added to the mixture and products were extracted with toluene. The organic layer was washed with brine and dried over sodium sulfate. Removal of the solvent gave 0.18 g of pale yellow oil, which was a mixture (92 : 8) of **5** (Me, Ph_2) and **6** (Me, Ph_2).

Conversion of 3 to Salicylic Acid Derivative 7. A mixture of 0.18 g (0.50 mmol) of **3** (Me, Ph_2) and 0.5 mmol of sodium ethoxide in 10 ml of ethanol was refluxed for 5 h. After cooling the mixture, 40 ml of water was added and products were extracted with toluene. The products were separated by column chromatography. The first toluene eluate gave 0.10 g (60%) of 2-(2-hydroxy-4,6-diphenylphenyl)-4,4-dimethyl-2-oxazoline **7** (H, Ph_2). The second ethyl acetate eluate gave 0.06 g (40%) of the deacylated product **9** (Ph_2) (vide infra).

Conversion of 4 to 5 by NaOEt. A solution of 0.43 g (1 mmol) of **4** (Ph_3) and 0.15 mmol of sodium ethoxide in 40 ml of ethanol was allowed to stand at r.t. for 1 h. To the yellow solution 60 ml of water and 60 ml of toluene were added. The organic layer was washed with brine and dried over sodium sulfate. After removal of the solvent in vacuo, 0.43 g of pure **5** (Ph_3) was obtained as colorless crystals.

Deacylation of 4 to 9. A solution of 107 mg (0.25 mmol) of **4** (Ph_3) and 0.48 g (8.6 mmol) of potassium hydroxide in 5 ml of ethanol was refluxed for 1 h. Cold water (50 ml) and toluene (50 ml) were added to the solution. The organic layer was washed with brine and dried over sodium sulfate. By removing the solvent in vacuo, 78 mg (0.24 mmol, 96%) of 4,6-diphenyl-7-oxa-1-azabicyclo[4.3.0]non-3(or 4)-en-2-one **9** (Ph_2) was obtained. Colorless needles (toluene–hexane); mp 186—188 °C; IR (KBr) 3066, 3028, 2976, 2885, 1655, 1610, 1446, 1404, 1381, 1275, 1022, 874, 767, 717, 705 cm^{-1}; ^{1}H NMR δ=1.55 (3H, s), 1.65 (3H, s), 3.27 (2H, m), 3.36 (1H, d, J=8.7 Hz), 3.79 (1H, d, J=8.7 Hz), 6.27 (1H, d, J=1.2 Hz), 7.2—7.4 (8H, m), 7.4—7.5 (2H, m); ^{13}C NMR δ=23.3 (q), 25.3 (q), 41.8 (t), 60.5 (s), 76.8 (t), 95.9 (s), 121.8 (d), 125.9 (d), 126.3 (d), 128.2 (d), 128.4 (d), 128.7 (d), 129.4 (d), 137.3 (s), 141.2 (s), 145.4 (s), 163.2 (s). Found: C, 78.97; H, 6.60; N, 4.48%. Calcd for $C_{21}H_{21}NO_2$: C, 78.97; H, 6.63; N, 4.39%.

Similarly, **9** (Ph, Bu) was obtained from **4** (Ph_2, Bu) in 97% yield. Colorless needles; mp 64—66 °C (toluene–hexane); IR (KBr) 3028, 2956, 2933, 1666, 1624, 1404, 1273, 1020, 1009, 854, 770, 706 cm^{-1}; ^{1}H NMR δ=0.71 (3H, t, J=7.2 Hz), 0.94—1.22 (4H, m), 1.51 (3H, s), 1.59 (3H, s), 1.95 (2H, t, J=7.3 Hz), 2.64 (1H, d, J=16.2 Hz), 2.91 (1H, dd, J=16.2 and 2.6 Hz), 3.29 (1H, d, J=8.8 Hz), 3.73 (1H, d, J=8.8 Hz), 5.72 (1H, d, J=2.6 Hz), 7.29—7.37 (5H, m); ^{13}C NMR δ=13.7 (q), 21.8 (t), 23.2 (q), 25.2 (q), 28.2 (t), 35.8 (t), 42.7 (t), 60.3 (s), 76.7 (t), 95.8 (s), 121.5 (d), 126.3 (d), 128.0 (d), 128.2 (d), 141.4 (s), 149.8 (s), 163.5 (s). Found: C, 74.29; H, 8.42; N, 4.54%. Calcd for $C_{19}H_{25}NO_2 \cdot 0.5H_2O$: C, 73.99; H, 8.50; N, 4.54%.

Similarly, 4,4-dimethyl-2-(5,5-dimethyl-4-oxo-2-phenyl-1-hexenyl)-2-oxazoline **9′** (*t*-Bu, Ph) was obtained from the deacylation of **3** (Ph, *t*-Bu, Ph) in 80% yield by refluxing the mixture for 3 h. Colorless needles; mp 88—89 °C (hexane); IR (KBr) 3056, 2970, 1701, 1635, 1358, 1309, 1147, 1065, 999, 974, 870, 766, 700 cm^{-1}; ^{1}H NMR δ=1.23 (9H, s), 1.29 (6H, s), 3.91 (2H, s), 4.37 (2H, s), 6.33 (1H, s), 7.32 (5H, s); ^{13}C NMR δ=26.9 (q), 28.4 (q), 41.2 (t), 44.4 (s), 67.1 (s), 78.2 (t), 117.2 (d), 126.2 (d), 128.3 (d), 128.5 (d), 142.1 (s), 146.9 (s), 161.2 (s), 211.7 (s). Found: C, 75.22; H, 8.46; N, 4.72%. Calcd for $C_{19}H_{25}NO_2 \cdot 0.25H_2O$: C, 75.09; H, 8.46; N, 4.61%.

Dealkylation of 4 to 10. General Procedure: A solution of **4** (0.2 mmol) and concd hydrochloric acid (2 ml) in ethanol (10 ml) was refluxed for 1 h. After the mixture was cooled, 50 ml of cold water and 50 ml of chloroform were added. The organic layer was washed with brine and dried over sodium sulfate and the solvent was removed in vacuo to give NMR-pure **10**.

10 (Ph_3):[13] Mp 279—280 °C (colorless needles from chloroform–hexane); IR (KBr) 3010, 2904, 1670, 1620, 1574, 1500, 1263, 966, 930, 920, 766, 760, 700, 687 cm^{-1}; ^{1}H NMR δ=6.66 (1H, s), 7.24—7.53 (11H, m), 7.66—7.68 (2H, m), 7.91—7.93 (2H, m), 12.15 (1H, broad s); ^{13}C NMR δ=106.9 (d), 126.6 (d), 126.7 (s), 128.1 (d), 128.5 (d), 128.6 (d), 129.0 (d), 129.2 (d), 129.4 (d), 130.5 (d), 132.6 (s), 133.2 (d), 137.5 (s), 137.6 (s), 147.1 (s), 153.5 (s), 162.8 (s), 195.2 (s).

10 (Me, Ph_2):[13] Mp 249.5—251.5 °C (pale yellow prisms from chloroform–hexane); IR (KBr) 3255, 3122, 3066, 2922, 1689, 1618, 1578, 1529, 1346, 1216, 1045, 762, 706, 659, 579 cm^{-1}; ^{1}H NMR δ=2.41 (3H, s), 6.61 (1H, s), 7.35—7.56 (8H, m), 7.82—7.87 (2H, m), 12.9 (1H, broad s); ^{13}C NMR δ=31.8 (q), 107.8 (d), 127.0 (d), 127.9 (d), 128.7 (d+s), 129.0 (d), 129.2 (d), 130.7 (d), 132.8 (s), 138.3 (s), 147.8 (s), 153.5 (s), 163.1 (s), 202.0 (s).

10 (Et, Ph_2): Mp 199—200 °C (colorless needles from chloroform–hexane); IR (KBr) 2910, 2900—2700 (br), 1699, 1618, 1529, 1498, 1470, 1448, 1192, 964, 945, 843, 762, 702, 690 cm^{-1};

^{1}H NMR δ=1.02 (3H, t, J=7.2 Hz), 2.66 (2H, q, J=7.2 Hz), 6.60 (1H, s), 7.36—7.49 (8H, m), 7.83—7.85 (2H, m), 13.15 (1H, broad s); ^{13}C NMR δ=7.8 (q), 37.8 (t), 107.4 (d), 127.0 (d), 127.9 (d), 128.5 (s), 128.7 (d), 129.0 (d), 129.1 (d), 130.5 (d), 132.7 (s), 138.1 (s), 147.2 (s), 152.6 (s), 163.1 (s), 205.3 (s). Found: C, 78.99; H, 5.52; N, 4.62%. Calcd for $C_{20}H_{17}NO_2$: C, 79.19; H, 5.65; N, 4.62%.

10 (*i*-Pr, Ph$_2$): Mp 219—221 °C (colorless needles from chloroform–hexane); IR (KBr) 3200, 2970, 2700, 1699, 1622, 1558, 1533, 1504, 1471, 984, 760, 694 cm^{-1}; ^{1}H NMR δ=0.96 (6H, d, J=6.9 Hz), 2.81 (1H, septet, J=6.9 Hz), 6.59 (1H, s), 7.36—7.49 (8H, m), 7.82—7.84 (2H, m), 13.0 (1H, broad s); ^{13}C NMR δ=17.8 (q), 41.3 (d), 107.2 (d), 127.0 (d), 128.2 (d), 128.4 (s), 128.6 (d), 129.0 (d), 129.1 (d), 130.4 (d), 132.8 (s), 138.2 (s), 147.0 (s), 152.4 (s), 163.0 (s), 208.4 (s). Found: C, 79.33; H, 6.03; N, 4.36%. Calcd for $C_{21}H_{19}NO_2$: C, 79.47; H, 6.03; N, 4.41%.

10 (*t*-Bu, Ph$_2$): Mp 257—258 °C (colorless needles from chloroform–hexane); IR (KBr) 2910, 3100—2600 (br), 1691, 1610, 1578, 1500, 972, 939, 781, 768, 754, 698, 579 cm^{-1}; ^{1}H NMR δ=0.90 (9H, s), 6.57 (1H, s), 7.39—7.49 (8H, m), 7.81—7.84 (2H, m), 13.2 (1H, broad s); ^{13}C NMR δ=27.0 (q), 45.0 (q), 106.8 (d), 126.9 (d), 128.6 (d), 128.8 (d), 129.0 (d), 129.1 (d), 129.6 (s), 130.2 (d), 132.9 (s), 138.4 (s), 146.2 (s), 149.9 (s), 163.0 (s), 213.2 (s). Found: C, 79.73; H, 6.35; N, 4.08%. Calcd for $C_{22}H_{21}NO_2$: C, 79.73; H, 6.39; N, 4.23%.

10 (Ph$_2$, Bu): Mp 209—210 °C (colorless needles from chloroform–hexane); IR (KBr) 2960, 2929, 2900—2700 (br), 1670, 1628, 1578, 1500, 1477, 1448, 1311, 1261, 1215, 935, 785, 766, 712, 694, 687 cm^{-1}; ^{1}H NMR δ=0.82 (3H, t, J=7.3 Hz), 1.29 (2H, sextet, J=7.4 Hz), 1.54 (2H, m), 2.46 (2H, t, J=7.9 Hz), 6.48 (1H, s), 7.11—7.34 (3H, m), 7.45—7.59 (5H, m), 7.96—7.98 (2H, m), 12.82 (1H, broad s); ^{13}C NMR δ=13.7 (q), 22.6 (t), 32.1 (t), 33.2 (t), 106.8 (d), 126.7 (d), 126.9 (s), 128.5 (d), 128.9 (d), 129.3 (d), 130.1 (d), 132.6 (s), 133.3 (s), 137.6 (s), 147.0 (s), 156.2 (s), 163.3 (s), 195.9 (s). Found: C, 79.43; H, 6.13; N, 4.05%. Calcd for $C_{22}H_{21}NO_2$: C, 79.73; H, 6.39; N, 4.23%.

10 (*t*-Bu, 2-furyl, Ph): Mp 241—243 °C (colorless needles from chloroform–hexane); IR (KBr) 3130, 2970, 2900—2700, 1693, 1618, 1560, 1533, 1473, 1348, 1244, 1182, 1159, 1092, 947, 885, 700, 579, 516 cm^{-1}; ^{1}H NMR δ=0.95 (9H, s), 6.52 (1H, dd, J=3.4 and 1.5 Hz), 6.75 (1H, s), 7.39—7.49 (5H, m), 7.50 (1H, d, J=1.5 Hz), 7.60 (1H, d, J=3.4 Hz), 13.68 (1H, broad s); ^{13}C NMR δ=27.0 (q), 45.1 (s), 103.9 (d), 111.8 (d), 112.5 (d), 128.6 (d), 128.8 (d), 129.10 (d), 129.14 (s), 136.5 (s), 138.3 (s), 144.3 (d), 146.5 (s), 150.2 (s), 162.6 (s), 213.1 (s). Found: C, 74.40; H, 5.94; N, 4.46%. Calcd for $C_{20}H_{19}NO_3$: C, 74.75; H, 5.96; N, 4.36%.

Dealkylation of 5 to 10. A solution of **5** (Ph$_3$) (100 mg, 0.24 mmol) and sulfuric acid (0.80 ml) in ethanol (8 ml) was refluxed for 24 h. Cold water (60 ml) and chloroform (60 ml) were added, and the organic layer was washed with brine and subsequently dried over Na_2SO_4. Removal of the solvent gave 80 mg (96%) of **10** (Ph$_3$).

Dealkylation of 9 to 11 A solution of **9** (Ph$_2$) (0.32 g, 1 mmol) and sulfuric acid (4 ml) in ethanol (40 ml) and water (4 ml) was refluxed for 24 h. After the mixture was cooled, water (60 ml) and chloroform (60 ml) were added and the organic layer was washed with brine and subsequently dried over Na_2SO_4. Removal of the solvent and crystallization from benzene gave 0.21 g (85%) of **11** (Ph$_2$).[21a] Mp 213—214.5 °C (colorless needles); IR (KBr) 3200—2600 (br), 3032, 2904, 1653, 1616, 1496, 955, 868, 764, 696, 563 cm^{-1}; ^{1}H NMR δ=6.75 (1H, d, J=1.5 Hz), 6.77 (1H, d, J=1.5 Hz), 7.41—7.54 (6H, m), 7.63—7.65 (2H, m), 7.81—7.82 (2H, m), 12.84 (1H, broad s); ^{13}C NMR δ=104.9 (d), 115.2 (d), 126.9 (d×2), 129.0 (d), 129.1 (d), 129.4 (d), 130.1 (d), 133.7 (s), 138.2 (s), 147.0 (s), 153.7 (s), 165.7 (s).

***N*-Methylation of 10 (Ph$_3$).** Treatment of 0.35 g (1.0 mmol) of **10** (Ph$_3$) with 0.43 g (3 mmol) of methyl iodide and 0.28 g (5 mmol) of KOH in 10 ml of methanol at reflux for 5 h, followed by silica-gel chromatography chloroform eluate gave 0.24 g (66%) of 3-benzoyl-1-methyl-4,6-diphenyl-2-pyridone. Mp 180—182 °C (colorless prisms from toluene–hexane); IR (KBr) 3062, 3033, 1670, 1633 (s), 1581, 1538, 1491, 1263, 1143, 769, 713, 704 cm^{-1}; ^{1}H NMR δ=3.44 (3H, s), 6.30 (1H, s), 7.22—7.52 (13H, m), 7.87—7.89 (2H, m); ^{13}C NMR δ=34.3 (q), 109.6 (d), 126.8 (s), 128.1 (d), 128.40 (d), 128.48 (d), 128.53 (d), 128.92 (d), 128.93 (d), 129.3 (d), 129.7 (d), 133.2 (d), 135.1 (s), 137.2 (s), 137.3 (s), 150.0 (s), 150.4 (s), 161.4 (s), 195.5 (s). Found: C, 82.08; H, 5.31; N, 3.80%. Calcd for $C_{25}H_{19}NO_2$: C, 82.17; H, 5.24; N, 3.83%.

Reaction of 1′ (Ph) with Diphenylpropynone. Treatment of 2-phenacyl-2-oxazoline, **1′** (Ph) (0.58 g, 3.07 mmol) with diphenylpropynone (0.66 g, 3.20 mmol) under condition A gave 3-benzoyl-1-(2-hydroxyethyl)-4,6-diphenyl-2-pyridone **4′** (Ph$_3$) (0.79 g, 67%, from toluene–ethyl acetate 2 : 1 eluate). Mp 94.5—95 °C (colorless prisms from toluene–hexane); IR (KBr) 3398, 3064, 1674, 1630, 1568, 1539, 1493, 1448, 1265, 1070, 764, 712, 700 cm^{-1}; ^{1}H NMR δ=3.73 (1H, t, J=5.2 Hz), 3.83 (2H, br q, J=5 Hz), 4.17 (2H, t, J=4.9 Hz), 6.53 (1H, s), 7.22—7.28 (3H, m), 7.29—7.49 (6H, m), 7.50—7.55 (4H, m), 7.88—7.90 (2H, m); ^{13}C NMR δ=49.7 (t), 62.8 (t), 110.8 (d), 127.1 (s), 128.1 (d), 128.59 (d), 128.61 (d), 128.7 (d), 129.0 (d), 129.2 (d), 129.3 (d), 129.8 (d), 133.4 (d), 134.7 (s), 136.8 (s), 137.1 (s), 150.5 (s), 150.8 (s), 162.9 (s), 195.1 (s). Found: C, 79.04; H, 5.36; N, 3.44%. Calcd for $C_{26}H_{21}NO_3$: C, 78.97; H, 5.35; N, 3.54%.

The authors thank Dr. Noriko Asaka for obtaining the elemental analyses data.

References

1) A. I. Meyers, D. L. Temple, R. L. Nolen, and E. D. Mihelich, *J. Org. Chem.*, **39**, 2778 (1974).

2) A. I. Meyers and D. L. Temple, *J. Am. Chem. Soc.*, **92**, 6644 (1970); A. I. Meyers, D. L. Temple, D. Haidukewych, and E. D. Mihelich, *J. Org. Chem.*, **39**, 2787 (1974); G. J. McGarvey, K. J. Wilson, and C. E. Shanholtz, *Tetrahedron Lett.*, **33**, 2641 (1992); J. K. I. Levin and S. M. Weinreb, *Tetrahedron Lett.*, **23**, 2347 (1982); A. I. Meyers and P. J. Reider, *J. Am. Chem. Soc.*, **101**, 2501 (1979).

3) A. I. Meyers, E. D. Mihelich, and R. L. Nolen, *J. Org. Chem.*, **39**, 2783 (1974).

4) I. C. Norden, *J. Heterocycl. Chem.*, **3**, 531 (1966).

5) J-E. Dubois and C. Lion, *C. R. Acad. Sci., Ser. C*, **274**, 303 (1972); J-E. Dubois and C. Lion, *Tetrahedron*, **29**, 3417 (1973).

6) S. Saito, H. Tamai, Y. Usui, and M. Inaba, *Chem. Lett.*, **1984**, 1243; M. Inaba, T. Moriwaki, and S. Saito, *Tetrahedron Lett.*, **26**, 3235 (1985).

7) Y. Tohda, T. Kawashima, M. Ariga, R. Akiyama, H. Shudoh, and Y. Mori, *Bull. Chem. Soc. Jpn.*, **57**, 2329 (1984).

8) Y. Tohda, M. Morikawa, T. Kawashima, M. Ariga, and Y. Mori, *Chem. Lett.*, **1986**, 273.

9) F. Castan, F. Denonne, and D. C. H. Bigg, *Synthesis*, **1993**, 1081.

10) a) Camptothecins: W. J. Slichenmyer, E. K. Rowinski, R. C. Donehower, and S. H. Kaufmann, *J. Natl. Cancer Inst.*, **85**, 271 (1993); D. P. Curran and H. Liu, *J. Am. Chem. Soc.*, **114**, 5863

(1992); b) EMD 69943: T. Koppe, W. W. K. R. Mederski, M. Osswald, and M. Schwarz, *Tetrahedron Lett.*, **36**, 377 (1995); c) Pyridoxatin: B. B. Snider and Q. Lu, *J. Org. Chem.*, **59**, 8065 (1994); d) (±)-Leporin A: B. B. Snider and Q. Lu, *J. Org. Chem.*, **61**, 2839 (1996); e) Huperzine A: A. P. Kozikowski, G. Campiani, L.-Q. Sun, S. Wang, A. Saxena, and B. P. Doctor, *J. Am. Chem. Soc.*, **118**, 11357 (1996); f) Cerpegin: H. Hong and D. L. Comins, *J. Org. Chem.*, **61**, 391 (1996); g) Funiculosin: D. R. Williams, P. D. Lowder, and Y-G. Gu, *Tetrahedron Lett.*, **38**, 327 (1997).

11) a) T. J. Murray and S. C. Zimmerman, *Tetrahedron Lett.*, **36**, 7627 (1995), and references therein; b) S. R. L. Fernando, U. S. M. Maharoof, K. D. Deshayers, T. H. Kinstle, and M. Y. Ogawa, *J. Am. Chem. Soc.*, **118**, 5783 (1996); c) A. Ichiba and S. Emoto, *Sci. Pap. Inst. Phys. Chem. Res. Jpn.*, **38**, 347 (1941).

12) a) D. L. Comins, M. F. Baevsky, and H. Hong, *J. Am. Chem. Soc.*, **114**, 10971 (1992); b) D. L. Comins, H. Hong, and G. Jianhua, *Tetrahedron Lett.*, **35**, 5331 (1994); c) F. G. Fang, S. P. Xie, and M. W. Lowery, *J. Org. Chem.*, **59**, 6142 (1994); d) S. S. Jew, K. D. Oh, H. J. Kim, M. G. Kim, J. M. Hah, and Y. S. Cho, *Tetrahedron: Asymmetry*, **6**, 1245 (1995); e) W. Shen, C. A. Coburn, W. G. Bornmann, and S. J. Danishefsky, *J. Org. Chem.*, **58**, 611 (1993); f) R. Jain, F. Roschangar, and M. A. Ciufolini, *Tetrahedron Lett.*, **36**, 3307 (1995); g) J. Barluenga, M. Tomás, A. Suarez-Sobrino, and V. Gotor, *Tetrahedron Lett.*, **29**, 4855 (1988).

13) A. Sammour, V. Akhnookh, and H. Jahine, *Univ. Roorkee Res. J., Chem.*, **14**, 213 (1971); *C. A.*, **77**, 411 (1972).

14) a) Y. Tohda, K. Sonogashira, and N. Hagihara, *Synthesis*, **1977**, 777; b) C. Chowdhury and N. G. Kundu, *Tetrahedron Lett.*, **37**, 7323 (1996); c) L. Brandsma, "Preparative Acetylenic Chemistry," 2nd ed, Elsevier, Amsterdam (1988), Chap. V.

15) K. Sonogashira, Y. Tohda, and N. Hagihara, *Tetrahedron Lett.*, **1975**, 4467; R. Rossi, A. Carpita, and F. Bellina, *Org. Prep. Proc.*, **27**, 129 (1995); K. R. Buszek and Y. Jeong, *Tetrahedron Lett.*, **36**, 5677 (1995).

16) a) From 1-alkynyltrimethylsilane: K. Utimoto, M. Tanaka, M. Kitani, and H. Nozaki, *Tetrahedron Lett.*, **1978**, 2301; G. E. Jones and A. B. Holmes, *Tetrahedron Lett.*, **23**, 3203 (1982); M. Karpf and A. S. Dreiding, *Helv. Chim. Acta*, **62**, 852 (1979); L. Birkofer, A. Ritter, and H. Uhlenbrauk, *Chem. Ber.*, **96**, 3280 (1963); D. P. Cox, J. Terpinski, and W. Lawrynowicz, *J. Org. Chem.*, **49**, 3216 (1984); b) From thiol esters: Y. Kawanami, T. Katsuki, and M. Yamaguchi, *Tetrahedron Lett.*, **24**, 5131, (1983); c) From 1-(benzotriazol-1-yl)propargyl ethyl ethers: A. R. Katritzky and H. Lang, *J. Org, Chem.*, **60**, 7612 (1995).

17) L. Palombi, L. Arista, A. Lattanzi, F. Bonadies, and A. Scettri, *Tetrahedron Lett.*, **37**, 7849 (1996); J. Bach, R. Berenguer, J. Garcia, T. Loscertales, J. Manzanal, and J. Vilarrasa, *Tetrahedron Lett.*, **38**, 1091 (1997).

18) M. Y. Joung, J. H. Ahn, and N. M. Yoon, *J. Org. Chem.*, **61**, 4472 (1996).

19) Z-T. Huang and X. Shi, *Synthesis*, **1990**, 162.

20) G. S. Poindexter, J. D. Catt, P. A. Sasse, and M. A. Kercher, *Heterocycles*, **36**, 295 (1993); S. Fustero, A. Navarro, D. Diaz, M. G. de la Torre, A. Asensio, F. Sanz, and M. L. Gonzalez, *J. Org. Chem.*, **61**, 8849 (1996).

21) a) E. P. Kohler, *J. Am. Chem. Soc.*, **44**, 379 (1922); b) R. M. Anker and A. H. Cook, *J. Chem. Soc.*, **1945**, 311; c) F. Bohlmann and D. Rahtz, *Chem. Ber.*, **90**, 2265 (1957).

22) The by-product may be formed via an abnormal Michael addition which often occurs in the case of stoichiometric use of strong base.[23] The reaction of **1** will be published.

23) R. M. Acheson, *Acc. Chem. Res.*, **4**, 177 (1971).

24) a) H. S. Mosher, "Heterocyclic Compounds," ed by R. C. Elderfield, John Wiley and Sons, New York (1950), Vol. 1, Chap. 8, p. 435; b) S. Mabic and N. Castagnoli, *J. Org, Chem.*, **61**, 309 (1996).

25) T. Koppe, W. W. K. R. Mederski, M. Osswald, and M. Schwarz, *Tetrahedron Lett.*, **36**, 377 (1995); H. Liu, S-B. Ko, H. Josien, and D. P. Curran, *Tetrahedron Lett.*, **36**, 8917 (1995); A. C. S. Reddy, B. Narsaiah, and R. V. Venkaratnam, *Tetrahedron Lett.*, **37**, 2829 (1996).

26) P. Allen and J. Ginos, *J. Org. Chem.*, **28**, 2759 (1963).