(*Z*)-Stereoselective Wittig Olefination of 2-Oxygenated Indol-3(2*H*)-ones

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The Wittig reaction of 1-acetyl-2-methoxy- (**1**) and 1-acetyl-2-hydroxyindol-3(2*H*)-one (**2**) with stabilized and semistabilized ylides gave predominantly 3-alkylidenedihydroindoles (**4**), (**7**), and (**13**) with (*Z*)-stereochemistry. When the Wittig reaction was carried out under more drastic conditions, the Wittig products (**4**) and (**7**) isomerized to afford 3-alkylindoles (**5**) and the indol-2-one (**8**), respectively. These isomerizations are also described.

The Wittig reaction is a powerful method for the stereocontrolled construction of carbon–carbon bonds.[1] It has recently been reported that α-oxygenated ketones react with stabilized ylides to give predominantly allylic oxygenated (*E*)-alkenes,[2] while with nonstabilized ylides mainly (*Z*)-alkenes are obtained.[3] Previously we briefly reported the reaction of stabilized ylides with the 2-methoxyindolone (**1**) as the α-oxygenated ketone which was employed as a key step in a synthesis of the carbazole alkaloid hyellazole.[4] We now report the stereoselective Wittig reaction of the 2-oxygenated indolones (**1**) and (**2**) with stabilized and semistabilized ylides to give preferentially (*Z*)-2-oxygenated 3-alkylidenedihydroindoles (**4**), (**7**), and (**13**), and their thermal isomerization to the indoles (**5**) and the indolone (**8**).

Results and Discussion

The 2-methoxy- (**1**)[5] and 2-hydroxyindolones (**2**)[6] are readily accessible by the oxidation of 1-acetylindole with oxodiperoxomolybdenum. When the 2-methoxyindolone (**1**) was treated with the acetonylidenephosphorane (**3a**) in boiling benzene for 5 h, (*Z*)-3-acetonylidenedihydroindole (**4a**), the (*E*)-isomer of (**4a**), and 3-acetonylindole (**5a**) were obtained in 50, 18, and 15% yields, respectively. The structures of these products were elucidated on the basis of spectroscopic properties and elemental analysis. In general, the allylic protons which are situated '*cis*' to the carbonyl group experience a downfield shift relative to the '*trans*' counterparts. The 2-methine proton of (*Z*)-(**4a**) appeared as a doublet (*J* 2 Hz) at δ 6.67 (1 H), to lower field than that [δ 5.83 (1 H, d, *J* 1 Hz)] of the isomer (*E*)-(**4a**). On the other hand, the aromatic 4-H [δ 8.70 (1 H, d, *J* 8 Hz)] of (*E*)-(**4a**) was observed at lower field than that [δ 7.47 (1 H, d, *J* 8 Hz)] of (*Z*)-(**4a**).

The isomerization of the dihydroindoles (*Z*)- and (*E*)-(**4a**), and the indole (**5a**) was examined, and the results are summarized in Table 3. In spite of prolonged heating, only slight isomerization of (*Z*)- to (*E*)-(**4a**) and *vice versa* was observed. This indicates that, in the Wittig reaction, (*Z*)- and (*E*)-(**4a**) are formed mainly as prime products without *Z*,*E*-isomerization. The formation of the indole (**5a**) from (*Z*)-(**4a**) can be rationalized in terms of a 1,5-hydrogen shift *via* a six-centre transition state (A).

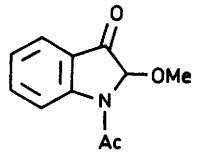
Similarly, the Wittig reaction of the indolone (**1**) with the ylides (**3b**, **c**) proceeded smoothly to afford predominantly the (*Z*)-alkenes (**4b**, **c**) with a small amount of the (*E*)-isomers. In contrast, the reaction with the ylide (**3d**) required longer heating for completion because of the lower reactivity of (**3d**),[1b] and the indole (**5d**) resulting from the isomerization of the Wittig product (**4d**) was mainly obtained. In refluxing toluene, the reaction of the indolone (**1**) with the ylides (**3a**, **d**) afforded the indoles (**5a**, **d**) in good yields, respectively. However, neither the reaction of (**1**) with the ylide (**3e**) nor that of the 2-benzyl derivative (**6**) with (**3a**) occurred in toluene under reflux.

The Wittig reaction of the 2-hydroxyindolone (**2**) was then examined. The 2-hydroxy derivative (**2**) was allowed to react with the stabilized ylide (**3a**) at room temperature to give a mixture of (*Z*)- and (*E*)-isomers of the 3-acetonylideneindole (**7**) (65%) in a ratio of 10:1, together with the indolone (**8**) (22%). The structure and stereochemistry of (**7**) were confirmed by comparison of its spectral data with that of the 2-methoxy derivatives, (*Z*)- and (*E*)-(**4a**). Although 2-hydroxydihydroindoles can exist in equilibrium with their acyclic tautomers,[7] in the case of (**7**), no evidence was found for the existence of the acyclic form (**9**) from its ^{1}H and ^{13}C NMR spectra in $CDCl_3$. The structure of the indolone (**8**) was assigned on the basis of spectral data and elemental analysis. The isomeric structure (**10**), which could be derived by the addition of the ylide (**3a**) to the aldehyde of the acyclic tautomer (**11**) of (**2**) followed by cyclization,† was readily ruled out by the ^{13}C NMR spectrum; two signals (δ 170.8 and 178.19) due to imide carbonyl carbons and a signal (δ 204.48) due to the ketone carbonyl carbon were observed. The Wittig reaction of the hydroxy derivative (**2**) occurred more rapidly than that of the methoxy derivative (**1**). This can be explained in terms of the activation of the carbonyl group of (**2**) by intra- or intermolecular hydrogen bonding.‡ The reaction of (**2**) with (**3a**) in boiling benzene afforded the indolone (**8**) in 78% yield. Therefore, the thermal transformation of (**7**) to (**8**) was attempted, but, in contrast with (**4**), no reaction occurred on heating (**7**) in refluxing benzene. However, by heating (**7**) in the presence of the ylide (**3a**) or triethylamine, the transformation smoothly occurred. This result indicates that the hydrogen bond between the 2-hydroxy and 3-acetonylidene groups in (**7**) inhibits the 1,5-hydrogen shift as observed in the isomerization of (*Z*)-(**4a**) to the indole (**5a**), and that the disruption of the hydrogen bond by addition of base permits the 1,5-hydrogen transfer reaction to occur to give indolone (**8**).

Finally, we investigated the Wittig reaction of the 2-methoxyindolone (**1**) with the semistabilized ylides (**12**). Treatment of (**1**) with the ylides (**12a**, **b**) at room temperature gave a mixture of (*Z*)- and (*E*)-isomers of the 3-arylmethylenedihydroindoles (**13a**, **b**) (49 and 55%) in ratios of 2.3:1 and

† Such a reaction was observed between 1-acetyl-2-hydroxy-2-methylindol-3(2*H*)-one with a stabilized ylide.[7]

‡ Although a linear O–H ··· O= hydrogen bonding arrangement is most favourable,[8] the intramolecular interaction in our case may have a more bent arrangement than that in the case of acyclic and six-membered cyclic α-hydroxy ketones.[2a]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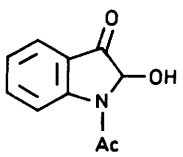
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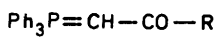
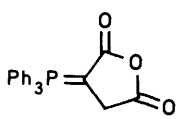

(3) a; R = Me
b; R = OMe
c; R = OBu^t
d; R = Ph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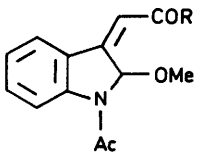
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b; R = OMe
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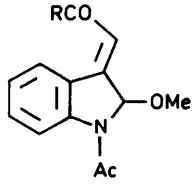
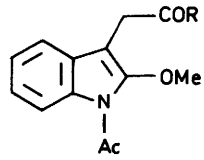
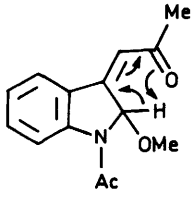
d; R = Ph


E-(4)


(5) a; R = Me
b; R = OMe
c; R = OBu^t
d R = Ph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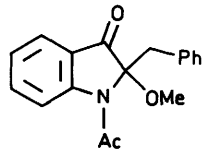

(6)

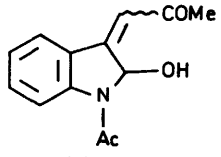
Table 1. Wittig reaction of the indolone (**1**) with the stabilized ylides (**3a–d**).

		Reaction conditions		% Yield[a]		
	R	Solv.	Time/h	(*Z*)-(**4**)	(*E*)-(**4**)	(**5**)
a	Me	Benzene	5	50	18	15
		Toluene	4	4	4	89
b	OMe	Benzene	3.5	91	8	
c	OBu^t	Benzene	3.5	78	17	
d	Ph	Benzene	18	Trace[b]		80
		Toluene	14	—	—	95

[a] Isolated yield. [b] Mixture of (*Z*)- and (*E*)-isomers in a ratio of 2:1.

5.5:1, respectively. The structure and stereochemistry of (**13a, b**) were established from spectral evidence (Table 2). In the ^{1}H NMR spectra of (*Z*)- and (*E*)-(**13a**), unlike the case of (*Z*)- and (*E*)-(**4**), the 4-H signal of (*E*)-(**13a**) appeared at higher field (δ 6.95, d) than that (δ 7.64, d) of (*Z*)-(**13a**). This is explained in terms of the shielding effect of the 3-aryl substituent of (*E*)-(**13a**) which cannot be coplanar with the other aromatic ring owing to steric repulsion.

Although a definitive mechanistic description for the Wittig reaction with stabilized ylides would at present be premature,[1a,9] the (*Z*)-stereoselectivity of the Wittig reaction may be due to the steric demand of the transition states in the nucleophilic attack of the ylide on the carbonyl carbon atom to form the oxaphosphetane, and/or in elimination of phosphine oxide from the oxaphosphetane to afford the alkene. In the Wittig reaction of α-hydroxy ketones with stabilized ylides,[2a] the initial interaction of the α-hydroxy group with the phosphorus centre of the ylide has been postulated as one mechanism. The 2-substituted 2-methoxy- (**6**) and 2-hydroxy-indolones[8] failed to undergo the desired Wittig reaction. If such an interaction is relevant in our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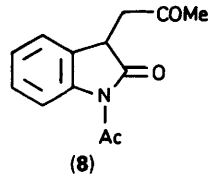
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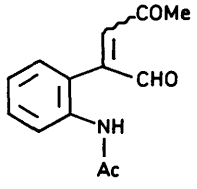
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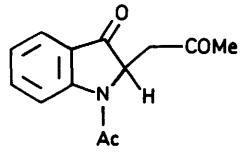
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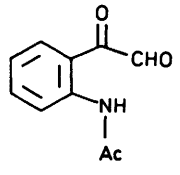

(11)

Table 2. ^{1}H NMR spectral data for the 3-alkylidenedihydroindoles (**4**), (**8**), and (**13**)[a]

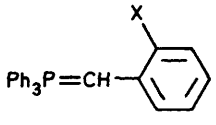
Compd.	2-H	4-H	7-H	Alkene	Ac	OMe	Aromatic	Others
(*Z*)-(**4a**)	6.67 (1 H, d[b])	7.47 (1 H, d)	8.20 (1 H, d)	6.73 (1 H, d[b])	2.37 (3 H, s)	3.05 (3 H, s)	7.00 (1 H, t) 7.35 (1 H, t)	2.40 (3 H, s)
(*E*)-(**4a**)	5.83 (1 H, d[c])	8.70 (1 H, d)	8.22 (1 H, d)	6.42 (1 H, d[c])	2.35 (3 H, s)	3.18 (3 H, s)	7.02 (1 H, t) 7.37 (1 H, t)	2.35 (3 H, s)
(*Z*)-(**4b**)	6.37 (1 H, d[b])	7.43 (1 H, d)	8.20 (1 H, d)	6.72 (1 H, d[b])	2.40 (3 H, s)	3.03 (3 H, s)	7.00 (1 H, t) 7.37 (1 H, t)	3.77 (3 H, s)
(*E*)-(**4b**)	5.82 (1 H, d[c])	8.65 (1 H, d)	8.18 (1 H, d)	6.02 (1 H, d[c])	2.33 (3 H, s)	3.02 (3 H, s)	7.00 (1 H, t) 7.32 (1 H, t)	3.75 (3 H, s)
(*Z*)-(**4c**)	6.35 (1 H, d[b])	7.45 (1 H, d)	8.23 (1 H, d)	6.72 (1 H, d[b])	2.42 (3 H, s)	3.05 (3 H, s)	7.02 (1 H, t) 7.37 (1 H, t)	1.53 (9 H, s)
(*E*)-(**4c**)	5.87 (1 H, d[c])	8.72 (1 H, d)	8.27 (1 H, d)	6.03 (1 H, d[c])	2.37 (3 H, s)	3.07 (3 H, s)	7.07 (1 H, t) 7.50 (1 H, t)	1.55 (9 H, s)
(**8**)[e] *Z*	6.52 (1 H, s)	7.54 (1 H, d)	8.30 (1 H, d)	6.76 (1 H, s)	2.42 (3 H, s)	—	7.12 (1 H, t) 7.44 (1 H, t)	2.47 (3 H, s) 5.12 (1 H, s)
E	5.78 (1 H, s)	8.74 (1 H, d)	8.23 (1 H, d)	6.52 (1 H, s)	*d*	—	*d*	*d*
(*Z*)-(**13a**)	6.19 (1 H, s)	7.64 (1 H, d)	8.29 (1 H, d)	7.35 (1 H, s)	2.39 (3 H, s)	3.09 (3 H, s)	7.02 (1 H, t) 7.33 (1 H, t) 7.89 (1 H, d)	7.15 (1 H, t) 7.44 (1 H, t) 7.94 (1 H, d)
(*E*)-(**13a**)	6.15 (1 H, s)	6.95 (1 H, d)	8.31 (1 H, d)	6.76 (1 H, s)	2.44 (3 H, s)	3.25 (3 H, s)	6.81 (1 H, t) 7.25 (1 H, t) 7.48 (1 H, d)	7.09 (1 H, t) 7.40 (1 H, t) 7.94 (1 H, d)
(*Z*)-(**13b**)	6.33 (1 H, s)	7.56 (1 H, d)	8.29 (1 H, d)	7.22 (1 H, s)	2.46 (3 H, s)	3.09 (3 H, s)	7.11 (1 H, t) 7.34 (1 H, t) 7.73 (2 H, d)	7.29 (1 H, t) 7.43 (2 H, t)
(*E*)-(**13b**)	6.07 (1 H, s)	6.73 (1 H, d)	8.27 (1 H, d)	6.90 (1 H, d)	2.42 (3 H, s)	3.15 (3 H, s)	6.7–7.6 (6 H, m)	

[a] Chemical shifts in ppm from internal Me_4Si; solvent is $CDCl_3$. [b] *J* 2 Hz. [c] *J* 1 Hz. [d] Unresolved because of superposition on other signals. [e] The spectrum of the mixture of (*Z*)- and (*E*)-isomers.

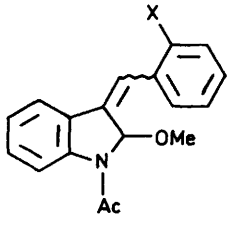
Table 3. Isomerization between the dihydroindoles (*Z*)- and (*E*)-(**4a**), and the indole (**5a**).[a]

Starting material	Ratio, %[b]		
	(*Z*)-(**4a**)	(*E*)-(**4a**)	(**5a**)
(*Z*)-(**4a**)	51	18	31
(*E*)-(**4a**)	13	84	3
(**5a**)	—	—	100

[a] The isomerization was carried out in refluxing benzene for 14 h. [b] The ratio was determined from ^{1}H NMR spectrum of the reaction mixture.



(**12**) **a**; X = I
b; X = H



(**13**) **a**; X = I
b; X = H

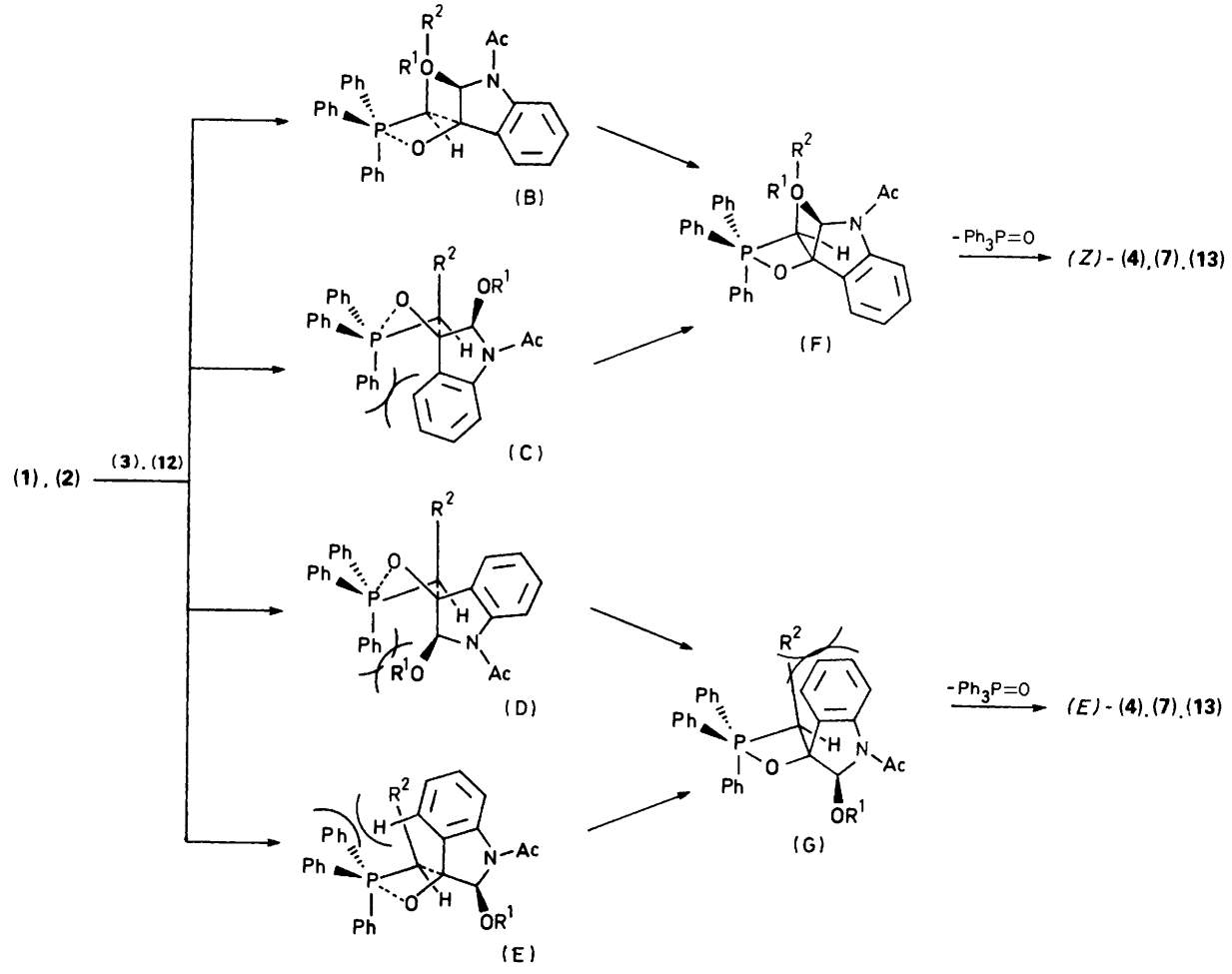
case, the Wittig reaction might not be affected by the additional 2-substituent. This indicates that the ylide adds to the carbonyl from the opposite side of the oxygenated group *via* the transition states (B–E) (puckered or planar approach of the ylide). Of these, the (*Z*)-selective transition state (B) is more favourable on the basis of considerations using Vedejs's model.[9a] Thus, the puckered geometries (C) (*Z*-selective) and (D) (*E*-selective) are less stable because of the 1,3-interaction between the ketone substituent and one of the *P*-phenyl groups in a pesudoaxial orientation. The (*E*)-selective variation (E) is undesirable because the pseudoaxial 4-site of the ketone encounters one (Ph′) of the *P*-phenyl groups. Alternatively, in the liberation of phosphine oxide from the oxaphosphetane (F) or (G), the intermediate (G) is less preferable because of the greater steric repulsion between the α-substituent (R^2) and the benzene ring of the indole nucleus.

2-Methoxy-3-alkylidenedihydroindoles are useful synthetic intermediates,[10] and are considered to produce the 3-alkylidene-1-acylindolium salts which have been postulated as reactive intermediates in synthetically important reactions.[11] The synthetic utility of these 2-oxygenated 3-alkylidenedihydroindoles is now under investigation.

Experimental

All m.p.s were determined with a Yanagimoto micromelting point apparatus and are uncorrected. IR spectra were recorded with a Hitachi 270-30 spectrophotometer. ^{1}H and ^{13}C NMR spectra were determined with JEOL JNM-PMX 60 and GX-400 spectrometers using tetramethylsilane as an internal standard. Mass spectra were obtained with a JEOL D-300 instrument with a direct inlet system operating at 70 eV. Elemental analyses were obtained by using a Perkin-Elmer Model 240B elemental analyser. Column chromatography was carried out on silica gel (Kanto Chemical Co. Inc., 100–200 mesh). 1-Acetyl-2-methoxy- (**1**)[5] and -2-hydroxy-indol-3(2*H*)-one (**2**),[6] and acetonylidene- (**2a**),[12] methoxycarbonylmethylene-(**3b**),[13] t-butoxycarbonylmethylene- (**3c**),[14] phenacylidene-(**3d**),[15] and 2,5-dioxo-2,3,4,5-tetrahydro-3-furylidene-triphenylphosphorane (**3e**)[16] were prepared according to the reported procedures.

General Procedure for the Reaction of the Methoxyindolone (**1**) *with the Stabilized Ylides* (**3a–d**).—A solution of the indolone (**1**) (2 mmol) and the ylides (**3a–d**) (4 mmol) in benzene or toluene (5 ml) was heated under reflux for the period indicated in Table 1. The reaction mixture was evaporated to dryness under reduced pressure. The residue was chromatographed on a silica gel column with hexane–ethyl acetate (3:1 or 4:1) or



methylene chloride as eluant to yield the indoles (**5a**) and (**5d**), the (*Z*)-alkylidenedihydroindoles (**4a–d**), and the (*E*)-isomers of (**4a–d**) successively, in that order. The yields and ^{1}H NMR spectra of (**4a–d**) are shown in Table 1 and 2, respectively.

(*Z*)-3-*Acetonylidene*-1-*acetyl*-2-*methoxy*-2,3-*dihydroindole* (**4a**) had m.p. 126–127.5 °C (from ether–ethyl acetate) (Found: C, 68.5; H, 6.2; N, 5.6. $C_{14}H_{15}NO_3$ requires C, 68.55; H, 6.2; N, 5.7%); ν_{max}($CHCl_3$) 1 682 (C=O) and 1 617 cm^{-1}; *m/z* 245 (M^+, 46%), 203 (39), 188 (69), 172 (47), and 160 (100%). The (*E*)-*isomer* of (**4a**) had m.p. 114.5–115.5 °C (from ether) (Found: C, 68.4; H, 6.2; N, 5.7%); ν_{max}($CHCl_3$) 1 684 (C=O) and 1 610 cm^{-1}; *m/z* 245 (M^+, 49%), 203 (52), 188 (100%), 172 (62), and 160 (49).

3-*Acetonyl*-1-*acetyl*-2-*methoxyindole* (**5a**) had m.p. 116–117.5 °C (from benzene–ether) (Found: C, 68.7; H, 6.15; N, 5.65. $C_{14}H_{15}NO_3$ requires C, 68.55; H, 6.2; N, 5.7%); ν_{max}($CHCl_3$) 1 705 (C=O) and 1 634 cm^{-1}; δ_H(60 MHz, $CDCl_3$) 2.18 (3 H, s, COMe), 2.60 (3 H, s, COMe), 3.67 (2 H, s, CH_2COMe), 3.92 (3 H, s, OMe), 7.1–7.35 (3 H, m, 4-, 5-, and 6-H), and 8.1–8.5 (1 H, m, 7-H); *m/z* 245 (M^+, 16%), 202 (11), and 160 (100%).

(*Z*)-1-*Acetyl*-2-*methoxy*-3-*methoxycarbonylmethylene*-2,3-*dihydroindole* (**4b**) had m.p. 109.5–110 °C (from ether–ethyl acetate) (Found: C, 64.4; H, 5.7; N, 5.3. $C_{14}H_{15}NO_4$ requires C, 64.4; H, 5.8; N, 5.4%); ν_{max}($CHCl_3$) 1 718, 1 680 (C=O), and 1 653 cm^{-1}; *m/z* 261 (M^+, 42%), 204 (30), 188 (100%), 172 (38), and 160 (47). The (E)-*isomer* of (**4b**) had m.p. 94.5–95.5 °C (from ether) (Found: C, 64.5; H, 5.8; N, 5.3%); ν_{max}($CHCl_3$) 1 717, 1 677 (C=O), and 1 643 cm^{-1}; *m/z* 261 (M^+, 41%), 204 (28), 188 (100%), 172 (34), and 160 (45).

(*Z*)-1-*Acetyl*-2-*methoxy*-3-*t-butoxycarbonylmethylene*-2,3-*dihydroindole* (**4c**) had m.p. 142.5–144 °C (from ether–ethyl acetate) (Found: C, 67.3; H, 7.1; N, 4.6. $C_{17}H_{21}NO_4$ requires C, 67.3; H, 7.0; N, 4.6%); ν_{max}($CHCl_3$) 1 708, 1 678 (C=O), and 1 651 cm^{-1}; *m/z* 303 (M^+, 18%), 247 (34), 190 (25), 188 (22), 174 (100%), and 160 (38). The (E)-*isomer* of (**4c**) had m.p. 140–142 °C (from hexane) (Found: C, 67.2; H, 7.1; N, 4.5%); ν_{max}($CHCl_3$) 1 708, 1 677 (C=O), and 1 647 cm^{-1}; *m/z* 303 (M^+, 16%), 247 (31), 190 (24), 188 (21), 174 (100%), and 160 (37).

1-*Acetyl*-2-*methoxy*-3-*phenacylidene*-2,3-*dihydroindole* (**4d**) was obtained as a yellow semisolid mixture of (*Z*)- and (*E*)-isomers, ν_{max}($CHCl_3$) 1 676 cm^{-1} (C=O); δ_H(60 MHz, $CDCl_3$) 2.41 and 2.43 (3 H, each s, COMe), 3.08 and 3.13 (3 H, each s, OMe), 6.05 (1/3 H, d, *J* 1 Hz, 2-H of *E*-isomer), 6.93 (2/3 H, d, *J* 2 Hz, 2-H of *Z*-isomer), 7.0–8.5 (9 H, m, Ph and ArH), and 8.60 (1/3 H, d, *J* 8 Hz, 4-H of *E*-isomer).

1-*Acetyl*-2-*methoxy*-3-*phenacylindole* (**5d**) had m.p. 166–167.5 °C (from benzene–ether) (Found: C, 74.35; H, 5.5; N, 4.5. $C_{19}H_{17}NO_3$ requires C, 74.25; H, 5.6; N, 4.6%); ν_{max}($CHCl_3$) 1 699 (C=O) and 1 636 cm^{-1}; δ_H(60 MHz, $CDCl_3$) 2.60 (3 H, s, COMe), 3.93 (3 H, s, OMe), 4.27 (2 H, s, CH_2COPh), 7.15–7.7 (6 H, m, ArH), and 7.9–8.5 (3 H, m, ArH); *m/z* 307 (M^+, 12%), 202 (19), and 160 (100%).

General Procedure for Isomerization between the Dihydroindoles (Z)- *and* (E)-(**4a**) *and the Indole* (**5a**).—A solution of (*Z*)-(**4a**), (*E*)-(**4a**), or (**5a**) (0.15 mmol) in benzene (1.5 ml)

was heated under reflux for 14 h. The mixture was concentrated under reduced pressure to give a mixture of (*E*)- and (*Z*)-(**4a**), and (**5a**), in a ratio which was determined by ^{1}H NMR spectroscopy (60 MHz, $CDCl_3$) (see Table 3).

Reaction of 1-*Acetyl*-2-*hydroxyindol*-3(2H)-*one* (**2**) *with the Stabilized Ylide* (**3a**).—(a) *Reaction in chloroform at room temperature.* A solution of the 2-hydroxyindolone (**2**) (0.19 g, 1 mmol) and the ylide (**3a**) (0.95 g, 3 mmol) in $CHCl_3$ (10 ml) was kept at room temperature for 39 h. The mixture was then concentrated under reduced pressure, and the residue chromatographed on silica gel. Elution with methylene chloride–ethyl acetate (5:1) gave 3-*acetonyl*-1-*acetylindol*-2(3H)-*one* (**8**) (0.05 g, 22%), m.p. 98.5–100 °C (from ether–ethyl acetate) (Found: C, 67.6; H, 5.6; N, 6.0. $C_{13}H_{13}NO_3$ requires C, 67.5; H, 5.7; N, 6.1%); ν_{max}($CHCl_3$) 1 755 and 1 717 cm^{-1} (C=O); δ_H(400 MHz, $CDCl_3$) 2.20 (3 H, s, COMe), 2.67 (3 H, s, COMe), 3.07 (1 H, dd, *J* 7 and 18 Hz, C*H*COMe), 3.28 (1 H, dd, *J* 3.7 and 18 Hz, C*H*COMe), 3.95 (1 H, dd, *J* 3.7 and 7 Hz, Ar–C*H*), 7.27–7.32 (3 H, m, 4-, 5-, and 6-H), and 8.22 (1 H, d, *J* 8.5 Hz, 7-H); δ_C(100 MHz, $CDCl_3$) 26.61 (q, Me), 29.80 (q, Me), 41.74 (d, Ar–*C*H), 44.57 (t, CH_2COMe), 116.56, 123.07, 125.04, and 128.44 (each d, ArC), 127.69 and 140.63 (each s, ArC), 170.82 and 178.19 (each s, NCO), and 204.48 (s, *C*OMe); *m*/*z* 231 (M^+, 10%), 188 (19), and 146 (100%). Further elution with the same solvent gave a mixture of the (*Z*)- and (*E*)-isomers of 3-acetonylidene-3-acetyl-2-hydroxy-2,3-dihydroindole (**7**) (0.15 g, 65%; *Z*:*E* = 10:1), m.p. 168–170 °C (from ether–ethyl acetate) (Found: C, 67.2; H, 5.75; N, 5.8. Calc. for $C_{13}H_{13}NO_3$: C, 67.5; H, 5.7; N, 6.1%); ν_{max}($CHCl_3$) 3 450 (OH) and 1 676 cm^{-1} (C=O); δ_C(100 MHz, $CDCl_3$) 23.49 (q, Me), 31.26 (q, Me), 83.58 (d, CHOH), 115.88, 117.66, 121.85, 124.08, and 134.27 (each d, ArC and =*C*HCO), 124.22, 146.90, and 154.18 (each s, ArC and *C*=CH), 169.73 (s, NCO), and 200.31 (s, CO); the signals due to the (*E*)-isomer were very weak; *m*/*z* 231 (M^+, 32%), 189 (21), 188 (20), and 146 (100%). ^{1}H NMR data are in Table 2.

(b) *Reaction in benzene under reflux.* A solution of the indolone (**2**) (0.327 g, 1.7 mmol) and the ylide (**3a**) (1.63 g, 5.1 mmol) in benzene (5 ml) was heated under reflux for 1 h. After removal of the solvent, the residue was purified by column chromatography on silica gel with methylene chloride–ethyl acetate (6:1) as eluant to give the indolone (**8**) (0.31 g, 78%), whose IR and ^{1}H NMR spectra were identical with those of the sample obtained in the preceding experiment.

Isomerization of the Acetonylidenedihydroindole (**7**) *to the Indolone* (**8**).—(a) *Reaction in the presence of the ylide* (**3a**). A solution of the indole (**7**) (31 mg, 0.13 mmol) and the ylide (**3a**) (43 mg, 0.13 mmol) in benzene (1.5 ml) was heated under reflux for 1.5 h. The reaction mixture was concentrated under reduced pressure. The residue was chromatographed on silica gel with methylene chloride as eluant to give the indolone (**8**) (15 mg, 48%) and the starting material (**7**) (5 mg, 16%).

(b) *Reaction in the presence of triethylamine.* A solution of (**7**) (52 mg, 0.22 mmol) and triethylamine (31 mg, 0.22 mmol) in benzene (3 ml) was heated under reflux for 5 h. After removal of the solvent, the residue was purified by silica gel column chromatography with methylene chloride as eluant to give (**8**) (32 mg, 62%).

General Procedure for the Reaction of the Indolone (**1**) *with the Semistabilized Ylides* (**12a**, **b**).—2-Iodobenzylidene- (**12a**) and benzylidene-triphenylphosphoranes (**12b**) were generated from 2-iodobenzyl- and benzyl-triphenylphosphonium bromide, respectively, according to Tagaki's procedure.[17] To a suspension of the indolone (**1**) (10 mmol) and the phosphonium salt (20 mmol) in benzene (20 ml), 20% aqueous NaOH (60 ml) was added with vigorous stirring at room temperature. The reaction mixture was stirred at the same temperature for 1–1.5 h, and diluted with benzene (300 ml). The organic layer was washed with water, dried over $MgSO_4$, and concentrated under reduced pressure. The residue was chromatographed on silica gel with $CHCl_3$–hexane (3:1) as eluant. ^{1}H NMR data are in Table 2.

1-*Acetyl*-3-(2-*iodobenzylidene*)-2-*methoxy*-2,3-*dihydroindole* (**13a**) was obtained as a mixture of (*Z*)- and (*E*)-isomers (49%; *Z*:*E* = 2.3:1), m.p. 128–129 °C (from hexane) (Found: C, 53.3; H, 3.9; N, 3.4. Calc. for $C_{18}H_{16}INO_2$: C, 53.35; H, 4.0; N, 3.5%); ν_{max}($CHCl_3$) 1 669 cm^{-1} (C=O); δ_H(60 MHz, $CDCl_3$) 2.40 and 2.45 (3 H, each s, COMe), 3.10 and 3.25 (3 H, each s, OMe), 6.17 (1 H, m, C*H*OMe), and 6.7–8.47 (9 H, m, ArH and =CH–); *m*/*z* 405 (M^+, 83%), 374 (25), 332 (44), 204 (100%), 176 (21), and 160 (39). Further purification of the mixture (**13a**) by column chromatography on silica gel with methylene chloride–hexane (3:1) as eluant gave (*Z*)-(**13a**), ν_{max}($CHCl_3$) 1 672 cm^{-1} (C=O), and (*E*)-(**13a**), ν_{max}($CHCl_3$) 1 674 cm^{-1} (C=O), respectively. The ^{1}H NMR spectra of (*Z*)- and (*E*)-(**13a**) are in Table 2.

1-*Acetyl*-3-*benzylidene*-2-*methoxy*-2,3-*dihydroindole* (**13b**) was obtained as a (*Z*)-(*E*)-mixture (55%; *Z*:*E* = 5.5:1), m.p. 137–138 °C (from hexane) (Found: C, 77.5; H, 6.1; N, 5.0. Calc. for $C_{18}H_{17}NO_2$: C, 77.4; H, 6.1; N, 5.0%); ν_{max}($CHCl_3$) 1 668 cm^{-1} (C=O); *m*/*z* 279 (M^+, 32%), 248 (26), and 206 (100%). Further purification of (**13b**) by column chromatography on silica gel with hexane–ethyl acetate (5:1) as eluant gave (*Z*)- and (*E*)-(**13b**) separately. ^{1}H NMR data are in Table 2.

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