Synthesis of New Nitrogen-Bridged Heterocycles. Reaction of Pyridinium *N*-Imines with Cyclopropenones

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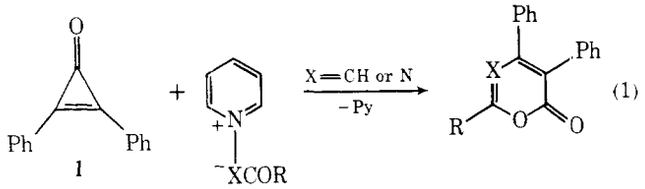
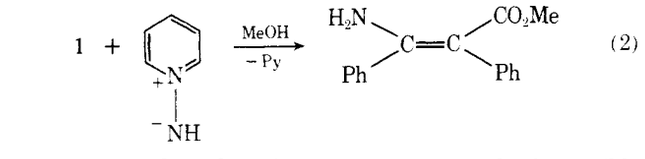
Pyridinium *N*-imine salts **3** and **5–8** reacted smoothly with methylphenylcyclopropenone (**2**) in methylene chloride in the presence of triethylamine at room temperature to give the corresponding 2-methyl-4-phenyl-3*H*-pyrido[1,2-*b*]pyridazin-3-ones **14–19** in fairly good yields. 4,4a-Dihydro intermediates **10–13** were isolated from the reactions of **3, 4,** and **9.** Reaction of **2** with **3** in methanol containing triethylamine afforded β-amino ester **22** in addition to **14.** Dipropylcyclopropenone (**24**) did not react with pyridinium *N*-imine salts in methanol containing triethylamine at room temperature, but did furnish 2,4-dipropyl-3*H*-pyrido[1,2-*b*]pyridazin-3-ones **25–28** with **3** and **5–7** under reflux conditions. Possible mechanisms of this reaction are discussed.

The cycloaddition reactions of pyridinium *N*-imines and pyridinium methylides with activated acetylenes serve as useful synthetic routes to a variety of pyrazolopyridines[1] and indolizines,[2] respectively. Although extension of these reactions to cyclopropenones would appear to offer promise for the preparation of other interesting bicyclic systems, in actual fact pyridinium ylides tend to react as nucleophiles with diphenylcyclopropenone (**1**) with loss of pyridine occurring in the process (eq 1[3,4] and 2[5]). Our observation[6] of the formation



(1)



(2)

of a 3*H*-pyrido[1,2-*b*]pyridazin-3-one as the result of a possible 1,3-dipolar cycloaddition reaction between pyridinium *N*-imine and methylphenylcyclopropenone represents the first evidence of behavior analogous to that of activated acetylenes for a cyclopropenone in these reactions. More recently, the reaction of pyridinium dicyanomethylide with **1** has been reported to yield a product of 1,3-dipolar cycloaddition.[7] However, utilization of 4-methylpyridinium dicyanomethylide in this reaction afforded a complex mixture of products, suggesting that the behavior of the parent ylide may be an exception. This paper describes the preparation of 3*H*-pyrido[1,2-*b*]pyridazin-3-ones from the reactions of various pyridinium *N*-imines with methylphenylcyclopropenone and di-*n*-propylcyclopropenone and the isolation of 4,4a-dihydro intermediates in certain cases.

Results and Discussion

The reactions of methylphenylcyclopropenone (**2**) with pyridinium *N*-imine salts **3–9** were carried out in methylene chloride in the presence of triethylamine (for **3–8**) or potassium carbonate (for **9**)[8] at room temperature. The results are summarized in Scheme I.

Reaction of the parent **3** with **2** afforded, after 17 h, both **10** (69%) and **14** (27%), while a 65-h reaction gave **10** (20%) and **14** (70%). A ready transformation of **10** to **14** was observed upon recrystallization attempts or excessive exposure to column chromatography. Also, **14** was obtained quantitatively from a benzene solution of **10** that had been heated under reflux for 16 h. The elemental analysis, NMR integration, and mass spectrum of **14** indicated that it was a dehydrogenation product of a 1:1 adduct. Evidence for the isomer bearing phenyl in the 4 position was obtained from the NMR spectrum of the 1:1 adduct **10,** which showed a one hydrogen doublet (J = 18 Hz) at δ 3.75 assigned to H_4. The magnitude of the coupling constant suggested a *trans*-diaxial relationship for H_4 and H_{4a}. Reaction of **4** with **2** produced **11** (19%, 35-day reaction time), whose NMR spectrum showed a one hydrogen singlet at δ 3.40, thus confirming the assignment. The 17-h reactions of other methyl-substituted pyridinium *N*-imine salts **5–8** gave the corresponding **15–19** in 62, 40, 20, 71, and 22% yields, respectively, where **16** and **17** are the two expected regioisomers from **6.** No dihydro intermediates were isolated in these cases. The observed predominance of cycloaddition at the sterically *less* hindered site (2:1) in the reaction of the unsymmetrically substituted **6** is, to the best of our knowledge, without precedence for this reagent. The cycloadditions of ethyl propiolate with a variety of 3-substituted pyridinium *N*-imines have been found to occur preferentially at the *more* hindered position, regardless of the electron-donating or electron-withdrawing character of the substituent.[1] Recently, the reaction of **6** with 2-phenylazirine has been reported to involve mainly cycloaddition at the *more* hindered site, where that of a pyridinium *N*-imine bearing at electron-withdrawing group at the 3 position, i.e., **9,** gave exclusively inverse orientation to the *less* hindered position.[9] With the objective of determining the effect of such a change in the electronic nature of the 3 substituent in **3** upon orientation in cycloaddition with **2,** the reaction of **9** was examined. A 12-day reaction (using potassium carbonate as base) produced only **12** (38%) and **13** (42%), whose NMR spectra showed characteristic one hydrogen doublets at δ 3.90 and 4.05 (J = 17 Hz), respectively. Treatment of these 4,4a-dihydro intermediates with palladium on carbon (10%) resulted in quantitative dehydrogenation to the corresponding aromatized derivatives **20** and **21,** whose H_8 multiplicities (see Table I) permitted the assignments of structures **12** and **13.** Thus, although a slight preference for the *more* hindered site was observed for the reaction of **9** with **2,** the change in the electronic character of the 3 substituent here did not affect orientation as dramatically as in the case of 2-phenylazirine above.

When the reaction of **2** with **3** was carried out in methanol containing triethylamine (24 h) the β-amino ester **22** was isolated as a pentane soluble oil (31%) in addition to **14** (67%).

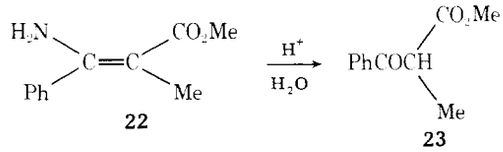


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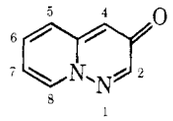
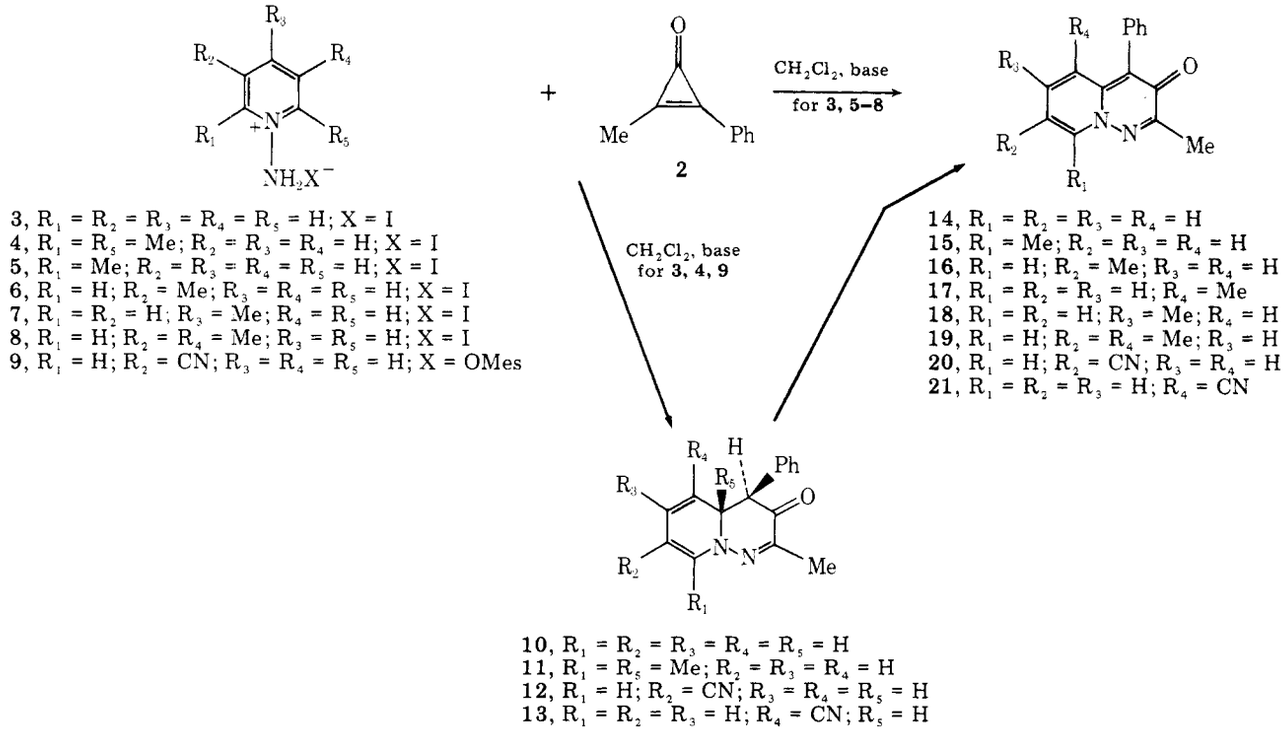
Table I. ^{1}H-NMR Spectral Data of Pyridopyridazinones ($CDCl_3$)



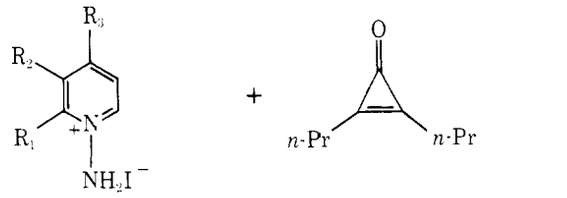
Compd	C_2	C_4	C_5	C_6	C_7	C_8
14	2.48 (s)	7.42 (s)		7.20 (m)	6.64 (m)	8.18 (d) (J = 7.0 Hz)
15	2.57 (s)	7.34 (s)		7.10 (m)	6.60 (m)	2.69 (s)
16	2.48 (s)	7.34 (s)		7.07 (m)	2.23 (s)	7.90 (s, br)
17	2.48 (s)	7.34 (s)	1.76 (s)	7.00 (d, br) (J = 7.0 Hz)	6.56 (t) (J = 7.0 Hz)	8.03 (d) (J = 7.0 Hz)
18	2.48 (s)	7.40 (s)	6.94 (s, br)	2.23 (s)	6.50 (dd) (J = 7.0, 1.5 Hz)	8.03 (d) (J = 7.0 Hz)
19	2.51 (s)	7.31 (s)	1.73 (s)	6.92 (s)	2.23 (s)	7.95 (s)
20	2.55 (s)	7.40 (m)		7.18 (m)		8.53 (s, br)
21	2.54 (s)	7.40 (m)		7.65 (dd) (J = 7.0, 1.5 Hz)	6.65 (t) (J = 7.0 Hz)	8.35 (dd) (J = 7.0, 1.5 Hz)
25	2.89 (t) 1.60 (m) 1.00 (t) (all J = 7.0 Hz)	2.78 (t)		7.33 (m)	6.66 (m)	8.13 (d) (J = 7.0 Hz)
26	3.00 (t) 1.80 (m) 1.07 (t)	2.88 (t) 1.05 (t)		7.33 (m)	6.67 (m)	2.73 (s)
27	2.89 (t) 1.66 (m) 1.00 (t)	2.76 (t)		7.26 (m)	2.30 (s)	8.00 (s)
28	2.92 (t) 1.68 (m) 1.00 (t)	2.78 (t)	7.12 (s, br)	2.37 (s)	6.55 (dd) (J = 7.0, 1.5 Hz)	8.06 (d) (J = 7.0 Hz)

Scheme I



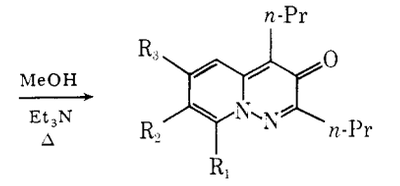
A quantitative hydrolysis of **22** to the β-keto ester **23** occurred on standing or on treatment with 10% sulfuric acid. The formation of **22** is viewed as a consequence of initial conjugate addition of pyridinium N-imine on the cyclopropenone ring with subsequent ring opening at the PhC–CO bond. This mode of ring opening has been observed in the reactions of **2** with 2-aminopyridines.[10] Although pyridinium N-imines have been found to react as 1,3-dipolar[1] or nucleophilic[11] reagents, the reaction of **2** with **3** in methanol apparently represents the first example of a possible dual behavior for this system in a

Scheme II



3, $R_1 = R_2 = R_3 = H$
5, $R_1 = Me$; $R_2 = R_3 = H$
6, $R_1 = H$; $R_2 = Me$; $R_3 = H$
7, $R_1 = R_2 = H$; $R_3 = Me$

24

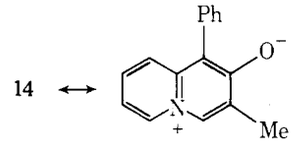


25, $R_1 = R_2 = R_3 = H$
26, $R_1 = Me$; $R_2 = R_3 = H$
27, $R_1 = H$; $R_2 = Me$; $R_3 = H$
28, $R_1 = R_2 = H$; $R_3 = Me$

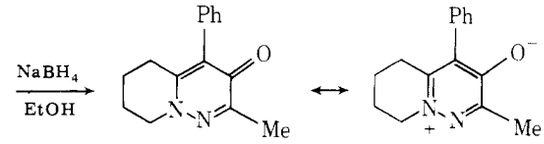
single reaction. The formation of both **22** and **14** here as opposed to the exclusive isolation of a β-amino ester in the case of diphenylcyclopropenone (**1**, eq 2) is consistent with the concept of a diminished reactivity in ring opening with nucleophiles for alkyl-substituted cyclopropenones.[10,12,13] The extension of this reaction to di-*n*-propylcyclopropenone (**24**) was therefore considered to be of interest.

No reaction was observed between pyridinium *N*-imines and **24** in methanol containing triethylamine during 5 days at room temperature, suggesting that both pathways are suppressed upon alkyl substitution in the cyclopropenone. Under reflux conditions, however, **24** did react with **3** and **5–7** to afford the corresponding **25–28** in 68 (2 days), 48 (10 days), 26 (12 days), and 53% (5 days) yields, respectively (see Scheme II). No absorption characteristic of methyl ester was observed in the NMR spectra of the crude residues. The adduct **25** from the parent imine **3** was isolated as the hydrate, as indicated by the elemental analysis. From the unsymmetrical **6**, only product **27**, corresponding to cyclization at the *less* hindered site, was observed, albeit in low yield. The ^1H NMR spectra of these adducts are strikingly similar to one another and also to those of **14–21** (see Table I).

While the IR spectra of all 4,4a-dihydro intermediates **10–13** showed characteristic carbonyl absorption at 1680–1690 cm^{-1}, those of the 3*H*-pyrido[1,2-*b*]pyridazin-3-ones **14–21** and **25–28** showed intense absorption below 1600 cm^{-1} only, suggesting that a charge-separated structure, i.e., **14a**, makes an important contribution to the resonance hybrid. This contribution may be reflected in the sodium borohydride reduction of **14** in ethanol, which afforded **29** in 61% yield. The mass spectrum of **29** indicated the incorporation of four hydrogens, while the NMR spectrum contained two 2 H triplets at δ 2.63 and 4.15. The IR spectrum of **29** showed intense absorption at 1605 and 1580 cm^{-1}, demonstrating the important role of an aromatic charge-separated structure, **29a**, in this case also.



14a



29 29a

In Scheme III, possible pathways to the 3*H*-pyrido[1,2-*b*]pyridazin-3-ones are presented for the reactions of **2** with **3–9**. One route (path a) involves initial 1,3-dipolar cycloaddition ($_\pi4_s + _\pi2_s$) of the pyridinium *N*-imines **30** with **2**, followed by opening of the cyclopropanone ring in **31** with transfer of the amino hydrogen to afford **32**. Although the isolated 4,4a-dihydro intermediates **10**, **12**, and **13** are apparently trans, initial formation of a *cis*-4,4a-dihydro intermediate cannot be ruled out, in as much as isomerization, under the basic conditions utilized, might be expected.[14] For this reason, the stereochemistry in **32** is not specified. An alternative route (path b) to **32** involves initial nucleophilic addition of **30** at the Me–C of **2** with proton transfer, followed by homo-1,5-dipolar cyclization ($_\pi4_s + _\sigma2_s$) of the resulting **33** or by cyclization of a 1,6-dipolar species **34** from **33**. This

Scheme III

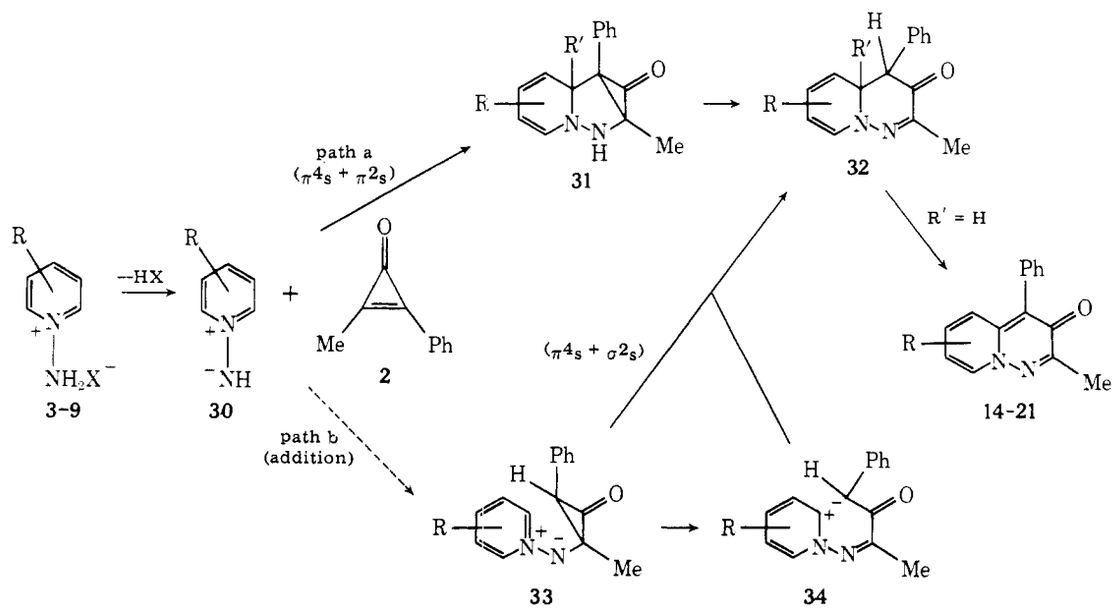


Table II. Results and Some Properties of Pyridopyridazinones

Compd[a]	Registry no.	Reactant: N-Imine	Reactant: Registry no.	Reactant: Cyclopropenone	Yield,[b] %	Mp, °C	IR (KBr), cm^{-1}
14	60047-71-4	**3**	6295-87-0	**2**	96[c]	201–203	1642 (m), 1600, 1580
15	66213-51-2	**5**	7583-90-6	**2**	62	171–173	1631 (m), 1600, 1597
16	66213-52-3	**6**	7583-91-7	**2**	40	142–144	1647 (w), 1601, 1581
17	66213-53-4	**6**		**2**	20	160–162	1640 (w), 1619, 1593
18	66213-54-5	**7**	7583-92-8	**2**	71	142–144	1649 (m), 1600, 1590
19	66213-55-6	**8**	7585-71-9	**2**[e]	22	165–167	1658 (w), 1612, 1579
20	66213-56-7	(**9**)	59065-90-6	(**2**)	100[d] (38)	205–207	2235, 1645 (w), 1605, 1592
(**12**)	66213-57-8						
21	66213-58-9	(**9**)		(**2**)	100[d] (42)	206–207	2230, 1640 (w), 1610, 1585
(**13**)	66213-59-0						
25	66213-60-3	**3**		**24**[f]	68	41–42	1643 (m), 1574
26	66213-61-4	**5**		**24**	48	80–82	1647 (m), 1592
27	66213-62-5	**6**		**24**	26	96.5–97.5	1660 (w), 1585
28	66213-63-6	**7**		**24**	53	70–71	1652 (m), 1577

[a] Anal. **14:** Calcd for $C_{15}H_{12}N_2O$: C, 76.25; H, 5.12; N, 11.86. Found: C, 76.15; H, 5.26; N, 11.89. **15:** Calcd for $C_{16}H_{14}N_2O$: C, 76.77; H, 5.64; N, 11.19. Found: C, 76.61; H, 5.64; N, 11.25. **16:** Found: C, 76.52; H, 5.81; N, 11.05. **17:** Found: C, 76.61; H, 5.67; N, 11.27. **18:** Found: C, 76.55; H, 5.76; N, 11.18. **19:** Calcd for $C_{17}H_{16}N_2O$: C, 77.25; H, 6.10; N, 10.60. Found: C, 77.24; H, 6.36; N, 10.46. **20:** Calcd for $C_{16}H_{11}N_3O$: C, 73.55; H, 4.24; N, 16.08. Found: C, 73.47; H, 4.31; N, 16.17. **21:** Found: C, 73.68; H, 4.35; N, 15.99. **25:** Calcd for $C_{14}H_{18}N_2O{\cdot}H_2O$: C, 67.71; H, 8.12; N, 11.28. Found: C, 67.45; H, 7.72; N, 11.11. **26:** Calcd for $C_{15}H_{20}N_2O$: C, 73.74; H, 8.25; N, 11.46. Found: C, 73.46; H, 8.29; N, 11.29. **27:** Found: C, 73.65; H, 8.15; N, 11.61. **28:** Found: C, 73.60; H, 8.41; N, 11.50. [b] Reaction times: **14–19,** 17 h; **12, 13,** 12 days; **25,** 2 days (reflux); **26,** 10 days (reflux); **27,** 12 days (reflux); **28,** 5 days (reflux). [c] Combined yields of **10** (69%) and **14** (27%). [d] From **12** or **13.** [e] Registry no. 26307-30-2. [f] Registry no. 698-93-1.

pathway may be contrasted with that suggested for the formation of β-amino ester **22,** wherein nucleophilic addition at the Ph–C of **2** results in rupture of the PhC–CO bond with elimination of pyridine.

The results of the present study, together with those obtained previously[5] with diphenylcyclopropenone, provide an interesting spectrum of reactivity for cyclopropenones in reactions with a reagent capable of both nucleophilic and dipolar behavior, a trend which may find application in the preparation of other novel heterocyclic systems.

Experimental Section

Melting points were obtained on a Mettler PF52 melting point apparatus and are uncorrected. Infrared spectra were taken on a Perkin-Elmer 337 spectrophotometer. NMR spectra were recorded with a Varian T-60 spectrometer using tetramethylsilane as an internal standard. The elemental analyses were performed by Alfred Bernhardt Laboratories, West Germany.

Materials. Pyridinium *N*-imine hydriodides **3–8** and mesitylene sulfonate **9** were prepared by Gösl's[15] and Tamura's[16] methods, respectively. Cyclopropenones **2**[17] and **24**[18] were also synthesized according to the literature.

Reactions of Pyridinium *N*-Imines with Cyclopropenones. A. Reactions with Methylphenylcyclopropenone 2 in Methylene Chloride. An equimolar mixture (2–4 mmol) of pyridinium *N*-imine salt and cyclopropenone **2** was treated with an excess of triethylamine (1.5 mL, 10 mmol) or potassium carbonate (5 g, used only for **9**) in methylene chloride (30–60 mL) at room temperature for 17 h (35 days for **4,** 12 days for **9**) and then the solvent was removed under reduced pressure. The crude residue was extracted with 4 80-mL portions of ether. The combined extracts were concentrated under reduced pressure, and the residue was separated by column chromatography on silica gel.

1. Isolation and Aromatization of Dihydropyridopyridazinones 10–13. Elution with benzene of the above residue from the reactions of **3, 4,** and **9** afforded the cycloadducts which in the cases of **10, 12,** and **13** were aromatized in benzene by heating or treatment with palladium on carbon (10%).

Isolation and Aromatization of 10. From the reaction of **3, 10** was obtained as an orange solid (69%): mp 135–137 °C; IR ($CHCl_3$) 1680, 1655, 1592 cm^{-1}; NMR ($CDCl_3$) δ 2.12 (3 H, singlet), 3.75 (1 H, doublet, J = 18.0 Hz, H_4), 5.05 (3 H, multiplet), 5.95 (1 H, multiplet), 6.80 (1 H, doublet, J = 7.0 Hz, H_8), 7.0–7.5 (5 H, multiplet).

Cycloadduct **10** (0.10 g) was treated in benzene (30 mL) at reflux temperature for 16 h to give **14** quantitatively: mp 201–203 °C (see Table II).

Isolation of 11. From the reaction of **4, 11** was obtained as an orange oil (19%): IR ($CHCl_3$) 1680, 1650, 1590 cm^{-1}; NMR ($CDCl_3$) δ 1.47 (3 H, singlet), 2.05 (3 H, singlet), 2.10 (3 H, singlet), 3.40 (1 H, singlet, H_4), 4.97 (2 H, multiplet), 5.60 (1 H, multiplet), 7.30 (5 H, singlet).

Cycloadduct **11** was unstable upon crystallization attempts or excessive exposure to column chromatography, furnishing unidentified decomposition products.

Isolation and Aromatization of 12 and 13. From the reaction of **9, 12** was obtained as an orange solid (38%) from the first fraction to be eluted with benzene: mp 176–177 °C; IR (KBr) 2205, 1690, 1645, 1585 cm^{-1}; NMR ($CDCl_3$) δ 2.18 (3 H, singlet), 3.90 (1 H, doublet, J = 17.0 Hz, H_4), 5.20 (2 H, multiplet), 6.0 (1 H, multiplet), 7.0–7.56 (6 H, multiplet).

From the second fraction to be eluted with benzene there was obtained **13** as a red solid (42%): mp 144–145 °C; IR (KBr) 2200, 1690, 1625, 1580 cm^{-1}; NMR ($CDCl_3$) δ 2.16 (3 H, singlet), 4.05 (1 H, doublet, J = 17.0 Hz, H_4), 5.25 (2 H, multiplet), 6.60–7.60 (7 H, multiplet).

Although cycloadduct **12** was stable in benzene solution at reflux temperature and **13** reacted only slowly under these same conditions, a smooth dehydrogenation could be effected using palladium on carbon (10%). Thus, a solution of **12** (0.10 g) in benzene (20 mL) containing palladium on carbon (0.10 g) was heated under reflux for 6 days to afford **20** quantitatively, while a similar treatment of **13** for 1.5 days produced **21** quantitatively (see Table II).

2. Isolation of Pyridopyridazinones 14–19. Elution with benzene–ether (1:1) of the residue from the reactions of **3** and **5–8** afforded the corresponding **14–19** as pale yellow to yellow crystalline solids. These results and some properties of the pyridopyridazinones are summarized in Table II.

B. Reaction of *N*-Imine 3 with Methylphenylcyclopropenone 2 in Methanol. A solution of pyridinium *N*-imine salt **3** (1.110 g, 5 mmol), cyclopropenone **2** (0.576 g, 4 mmol), and triethylamine (1.5 mL, 10 mmol) in 80 mL of dry methanol was allowed to stand for 24 h at room temperature during which time it developed a dark red coloring. The solvent was then removed under reduced pressure and the crude residue was extracted with three 80-mL portions of ether. The combined extracts were concentrated under reduced pressure and this residue was extracted with three 30-mL portions of pentane from which there was obtained 0.240 g (31%) of methyl α-methyl-β-amino-*trans*-cinnamate (**22**) as a pale yellow oil: IR ($CHCl_3$) 3492, 3316, 1660, 1600 cm^{-1}; NMR ($CDCl_3$) δ 1.60 (3 H, singlet), 3.69 (3 H, singlet), 6.0–7.0 (2 H, broad), 7.30 (5 H singlet). Hydrolysis of **22** in 10% H_2SO_4 (40 h at room temperature) produced methyl α-benzoylpropionate (**23**) quantitatively, identical in all respects with an authentic sample.[19]

Recrystallization of the pentane-insoluble fraction from methylene

chloride–pentane afforded 14 (0.644 g, 67%), identical to the material isolated from the reaction of 2 with 3 in methylene chloride.

C. Reactions with Dipropylcyclopropenone 24 in Methanol. A solution of pyridinium *N*-imine salt (2.5 mmol), triethylamine (0.75 mL, 5 mmol), and cyclopropenone **24** (0.276 g, 2 mmol) in 50 mL of dry methanol was heated under reflux until the IR spectrum of an aliquot no longer demonstrated the presence of cyclopropenone. The residue of the workup as in A was separated by column chromatography on silica gel using benzene–ether as an eluent. The results are summarized in Table II.

Sodium Borohydride Reduction of 2-Methyl-4-phenyl-3*H*-pyrido[1,2-*b*]pyridazin-3-one (14). Sodium borohydride (80 mg, 2.1 mmol) was added to a solution of 14 (118 mg, 0.5 mmol) in 15 mL of absolute ethanol. After 17 days at room temperature (additional 80-mg portions of sodium borohydride were added on the 6th and 14th days), the solvent was evaporated and the resulting white solid was treated with 10% aqueous ammonium chloride (30 mL). An ether extract (100 mL) was dried over $MgSO_4$, filtered, and evaporated to give a yellow oil which was separated by column chromatography on silica gel using benzene–ether as an eluent to afford 73 mg (61%) of a white solid: mp 164–166 °C; mass spectrum *m/e* (rel intensity) 240 (65, M^+), 239 [100, $(M-1)^+$], 212 [13, $(M-CO)^+$]; IR (KBr) 1605, 1580 cm^{-1}; NMR ($CDCl_3$) δ 1.10–2.20 (4 H, multiplet), 2.36 (3 H, singlet), 2.63 (2 H, triplet, J = 6.0 Hz), 4.15 (2 H, triplet, J = 6.0 Hz), 7.05–7.45 (5 H, multiplet). Anal. Calcd for $C_{15}H_{16}N_2O$: C, 74.97; H, 6.71; N, 11.66. Found: C, 74.97; H, 6.78; N, 11.83.

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Registry No.—**4**, 36012-28-9; **10**, 66213-64-7; **11**, 66213-65-8; **22**, 66213-66-9; **29**, 60047-73-6.

References and Notes

(1) Y. Tamura, Y. Sumida, Y. Miki, and M. Ikeda, *J. Chem. Soc., Perkin Trans. 1*, 406 (1975), and references therein.
(2) V. Boekelheide and K. Fahrenholtz, *J. Am. Chem. Soc.*, **83**, 458 (1961).
(3) T. Eicher and A. Hansen, *Tetrahedron Lett.*, 1169 (1967).
(4) T. Sasaki, K. Kanematsu, and A. Kakehi, *J. Org. Chem.*, **36**, 2451 (1971).
(5) A. Kascheres and D. Marchi, Jr., *J. Org. Chem.*, **40**, 2985 (1975).
(6) A. Kascheres and D. Marchi, Jr., *Chem. Commun.*, 275 (1976).
(7) K. Matsumoto and Y. Koni, *Chem. Commun.*, 1045 (1976).
(8) Reaction of **2** with **9** in the presence of triethylamine resulted in immediate darkening of the solution and low yields of products.
(9) A. Kakehi, S. Ito, T. Manabe, H. Amano, and Y. Shimaoka, *J. Org. Chem.*, **41**, 2739 (1976).
(10) A. Kascheres, C. Kascheres, J. A. R. Rodrigues, and A. A. Santana, *J. Org. Chem.*, **41**, 3546 (1976).
(11) T. Sasaki, K. Kanematsu, and A. Kakehi, *J. Org. Chem.*, **37**, 3106 (1972).
(12) R. Breslow and R. Peterson, *J. Am. Chem. Soc.*, **82**, 4426 (1960).
(13) E. V. Dehmlow, *Tetrahedron Lett.*, 5177 (1967).
(14) Examination of the NMR spectra of the crude products from shorter reaction times failed to reveal the presence of possible *cis*-4,4a-dihydro intermediates.
(15) R. Gösl and A. Neuwsen, *Org. Synth.*, **43**, 1 (1963).
(16) Y. Tamura, J. Minamikawa, Y. Miki, S. Matsugashita, and M. Ikeda, *Tetrahedron Lett.*, 4133 (1972).
(17) A. Krebs and J. Breckwoldt, *Tetrahedron Lett.*, 3797 (1969).
(18) R. Breslow, L. J. Altman, A. Krebs, E. Mohacsi, and I. Murata, R. A. Peterson, and J. Posner, *J. Am. Chem. Soc.*, **87**, 1326 (1965).
(19) H. B. Kagan and Y. Heng Suen, *Bull. Soc. Chim. Fr.*, 1819 (1966).

Synthesis Using Allylidenedihydropyridines. 3.[1] Synthesis and Thermolysis of Functionalized 2-Allylidene-1,2-dihydropyridines

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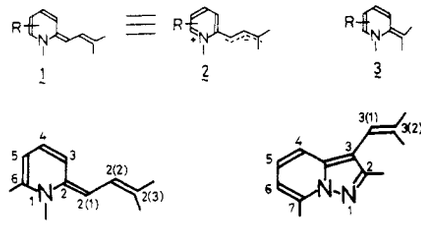
Some 2-allylidene-1,2-dihydropyridines (**19–24**) possessing an electrophilic center in the 1-substituent were prepared by the reactions of pyridinium salts **10, 13,** and **14** with ethoxymethylene compounds **17** and **18** in the presence of alkali, and they were converted in high yields to the corresponding 3-ethenylpyrazolo[1,5-*a*]pyridines **25, 26,** and **29–32** with elimination of ethyl *N*-methylcarbamate **38** by heating in refluxing xylene. On the other hand, the reactions of pyridinium salts **11** + **12** and **15** with the same reagents, **17** and **18,** did not give the corresponding allylidenedihydropyridines, but directly afforded pyrazolopyridines **27, 28, 33,** and **34** in comparatively high yields.

Although 2-allylidene-1,2-dihydropyridine **1** is a vinylog of 2-methylene-1,2-dihydropyridine **3** which is one of the most important precursors in the indolizine synthesis,[2] its versatility as a source of heterocycles has not been investigated at all. Since this molecule **1** has also the contribution of the ionic



structure **2**, in which the negative charge delocalizes on the 2-allylidene group, its nucleophilic reaction due to this structure **2** would be expected.

Recently, we have reported a simple and widely applicable preparative method for allylidenedihydropyridines[3] and the formation of functionalized 2-allylidene-1,2-dihydropyridines[4] using this route. This paper describes the preparations of some 2-allylidene-1,2-dihydropyridines possessing an electrophilic center and their conversions to 3-ethenylpyrazolo[1,5-*a*]-pyridines.

Results and Discussion

Preparations of Pyridinium Salts 10–16. Pyridinium salts possessing an electrophilic center in the 1-substituent were prepared by the alkylation of various 2-picolinium *N*-ylides which can act not only as 1,3-dipoles but also as 1,5-dipoles:[5] treatment of 1-imidoylimino- (**4–7**),[5h] 1-vinylimino- (**8**), and 1-ethoxycarbonyliminopyridinium ylide (**9**)[5a] with methyl iodide at room temperature afforded the corresponding pyridinium salts **10, 11** + **12,** and **13–16** in quantitative yields, respectively (Scheme I).

Since the formations of various types of pyridinium salts might be possible via the alkylation, the structures of the resulting pyridinium salts **10–16** were indicated by their NMR spectra (Table I) and the thermal behavior of the corresponding allylidenedihydropyridines derived from the pyri-

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