Heterocyclization Reaction of 2-(2-Methylaziridin-1-yl)-3-ureidopyridines under Appel's Conditions

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The reaction of 2-(2-methylaziridin-1-yl)-3-ureidopyridines **12** with triphenylphosphine, carbon tetrachloride, and triethylamine (Appel's conditions) led to the corresponding carbodiimides **13**, which underwent intramolecular cycloaddition reaction with aziridine under the reaction conditions to give the pyridine-fused heterocycles, 2,3-dihydro-1*H*-imidazo[2',3':2,3]imidazo[4,5-*b*]pyridines **16** and 12,13-dihydro-5*H*-1,3-benzodiazepino[2',3':2,3]imidazo[4,5-*b*]pyridines **17**.

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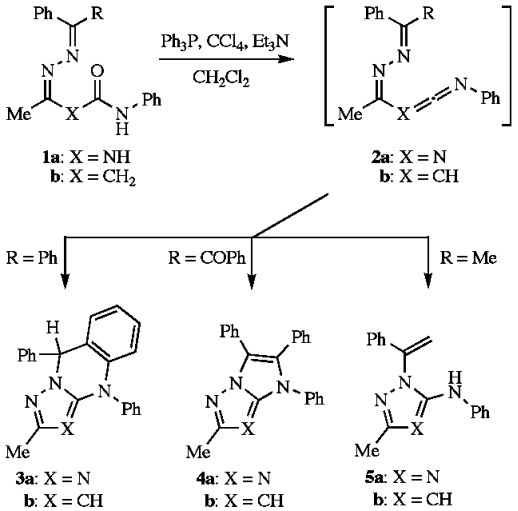
The cycloaddition of three-membered ring heterocycles with heterocumulenes is a useful method for the formation of five-membered ring heterocycles. Aziridines and aziridinium salts are known to undergo ring expansion with a variety of unsaturated functional groups such as aldehydes [1], ketones [2], thioketones [3], imines [4], carbon dioxide [5,6], carbon disulfide [6], isocyanates [7], isothiocyanates [6,7], carbodiimides [8], and sulfur diimides [9].

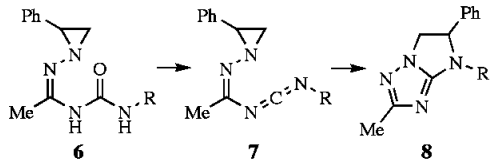
The electrocyclic reaction of conjugated heterocumulenes is a synthetic route to heterocycles [10]. Recently we described a new route to 1,2,4-triazole-fused heterocycles such as 5,10-dihydro-1,2,4-triazolo[5,1-*b*]quinazolines **3a** [11], 7*H*-imidazo[1,2-*b*][1,2,4]triazole **4a** [12], and monocyclic *N*-α-styryl-5-(phenylamino)-1,2,4-triazole **5a** [13] involving electrocyclization of azinocarbodiimides **2a** obtained from the corresponding ureas **1a** using Appel's dehydration method [14]. In addition, we reported [15] that azinoketimines **2b**, which were obtainable from the corresponding amides **1b** under similar condition, gave pyrazole-fused heterocycles such as 4,9-dihydropyrazolo[5,1-*b*]quinazoline **3b**, 1*H*-imidazo[1,2-*b*]pyrazole **4b**, and monocyclic *N*-α-styryl-5-(phenylamino)-pyrazole **5b** by thermal rearrangement (Scheme I).

Scheme I



We published [16] a new synthesis of 5,6-dihydro-7*H*-imidazo[1,2-*b*]triazoles **8** involving intramolecular cycloaddition reaction of *N*-aziridinylimino carbodiimides **7** obtained from the corresponding ureas **6** using Appel's dehydration condition as shown in Scheme II. We now report that 2-(2-methylaziridin-1-yl)-3-ureidopyridines **12** in the Appel's dehydration condition give pyridine-fused heterocycles **16** and **17**. Biological activities of structurally similar pyridine containing molecules are known as pharmaceutical agents [17].

Scheme II



The urea starting materials **12** employed in this study, were prepared from the 2-chloro-3-nitropyridine (**9**) in three sequential steps as depicted in Scheme III. 2-Chloro-3-nitropyridine (**9**) was reacted with 2-methylaziridine in the presence of triethylamine in tetrahydrofuran at room temperature for 8 hours to give 2-(2-methylaziridin-1-yl)-3-nitropyridine (**10**) in 94% yield. 3-Nitropyridine **10** on hydrogenation over 5% palladium on charcoal in tetrahydrofuran gave 82% yield of 3-aminopyridine **11** at room temperature and atmospheric pressure. Compound **11** was reacted with an equivalent of isocyanates in dichloromethane at room temperature to give 2-(2-methylaziridin-1-yl)-3-ureidopyridines **12** in 72-88% yields (Table 1).

Treatment of *N*-arylureas **12a-d** with triphenylphosphine, carbon tetrachloride, and triethylamine in refluxing dichloromethane for 3-24 hours afforded the pyridine-fused heterocycles, 2,3-dihydro-1*H*-imidazo[2',3':2,3]imidazo[4,5-*b*]pyridines **16a-d** and 12,13-dihydro-5*H*-1,3-benzodiazepino[2',3':2,3]imidazo[4,5-*b*]pyridines **17a-d**, and which constitute relatively unexplored or unknown classes of compounds. A suitable mechanism for the

Table 1

2-(2-Methylaziridin-1-yl)-3-ureidopyridines **12**

	R	Time (h)	Yield (%)	Mp (°C)	Molecular Formula	Analysis % Calcd./Found C	H	N
12a	C_6H_5	2	88	119-120	$C_{15}H_{16}N_4O$ (268.31)	67.15 67.01	6.01 5.88	20.88 20.61
12b	*p*-ClC_6H_4	3	78	144-145	$C_{15}H_{15}ClN_4O$ (302.76)	59.51 59.27	4.99 4.81	18.51 18.30
12c	*o*-FC_6H_4	3	85	130-131	$C_{15}H_{15}FN_4O$ (286.30)	62.93 62.70	5.28 5.02	19.57 19.36
12d	*p*-$MeOC_6H_4$	3	72	136-137	$C_{16}H_{18}N_4O_2$ (298.34)	64.41 64.19	6.08 5.87	18.78 18.54
12e	C_6H_5CO	4	77	176-177	$C_{16}H_{16}N_4O_2$ (296.32)	64.85 65.12	5.44 5.19	18.91 18.65
12f	*p*-ClC_6H_4CO	4	75	180-181	$C_{16}H_{15}ClN_4O_2$ (330.77)	58.10 57.85	4.57 4.32	16.94 16.70
12g	*p*-MeC_6H_4CO	4	73	178-179	$C_{17}H_{18}N_4O_2$ (310.35)	65.79 65.98	5.85 6.08	18.05 17.82

formation of **16** and **17** is depicted in Scheme III. Although the isolation of carbodiimides **13** was unsuccessful under the reaction conditions, an intramolecular cycloaddition reaction of aziridinyl cabodiimides **13** gives the zwitterionic aziridinium ions **14** followed by aziridine ring opening to afford the resonance-stabilized zwitterionic transition states, or intermediates **15a-c**, and ring closure to give **16a-d** (35-45%) and **17a-d** (8-10%) after rearomatization. The *N*-benzoylureas **12e-g**, in contrast, yielded a single product, 2,3-dihydro-1*H*-imidazo[2',3':2,3]imidazo-

Scheme III

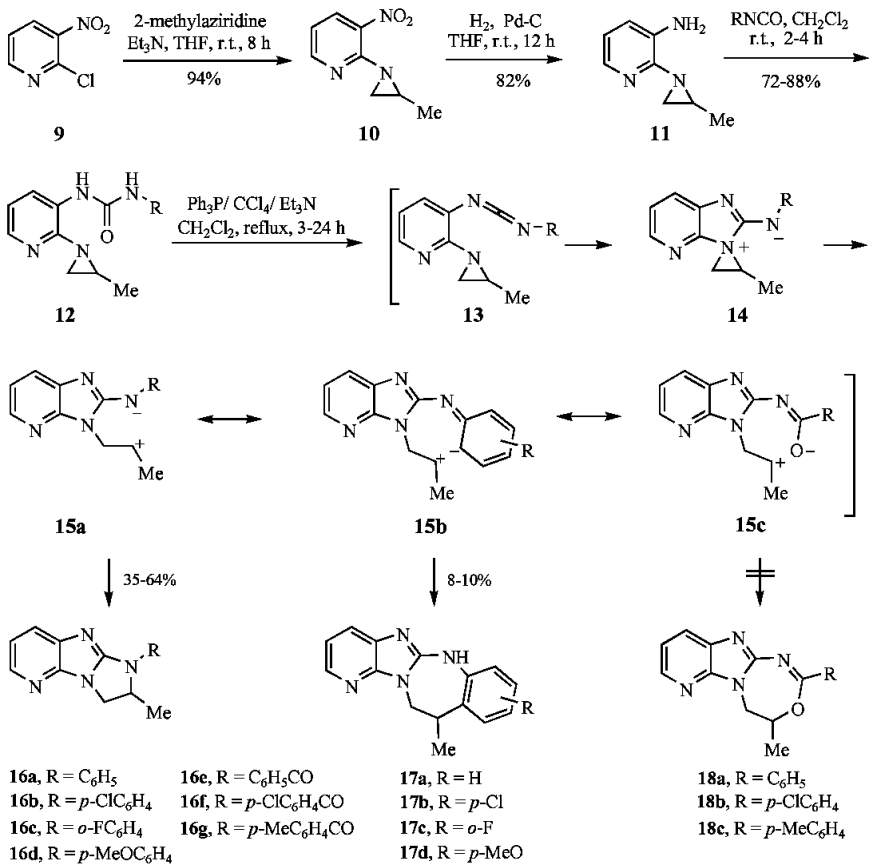


Table 2

Pyridine-Fused Heterocycles **16** and **17**

	R	Time (h)	Yield (%)	MP (°C)	IR (cm^{-1}) ν [a] C=O/NH	Molecular Formula	Analysis % Calcd./Found C	H	N
16a	C_6H_5	20	45	154		$C_{15}H_{14}N_4$	71.98	5.64	22.38
						(250.30)	71.81	5.40	22.15
17a	H	20	8	138	3440	$C_{15}H_{14}N_4$	71.98	5.64	22.38
						(250.30)	71.75	5.59	22.20
16b	*p*-ClC_6H_4	3	38	149		$C_{15}H_{13}ClN_4$	63.27	4.60	19.68
						(284.74)	63.02	4.43	19.81
17b	*p*-Cl	3	10	174	3417	$C_{15}H_{13}ClN_4$	63.27	4.60	19.68
						(284.74)	62.95	4.51	19.40
16c	*o*-FC_6H_4	17	35	138		$C_{15}H_{13}FN_4$	67.15	4.88	20.88
						(268.29)	66.86	4.62	20.61
17c	*o*-F	17	10	142	3429	$C_{15}H_{13}FN_4$	67.15	4.88	20.88
						(268.29)	66.89	4.59	20.57
16d	*p*-$MeOC_6H_4$	24	45	129		$C_{16}H_{16}N_4O$	68.55	5.75	19.99
						(280.32)	68.30	5.58	19.76
17d	*p*-MeO	24	9	105	3409	$C_{16}H_{16}N_4O$	68.55	5.75	19.99
						(280.32)	68.32	5.70	19.71
16e	C_6H_5CO	5	64	209	1631	$C_{16}H_{14}N_4O$	69.05	5.07	20.13
						(278.31)	68.82	5.18	19.85
16f	*p*-ClC_6H_4CO	3	52	217	1607	$C_{16}H_{13}ClN_4O$	61.44	4.19	17.91
						(312.75)	61.69	4.01	17.75
16g	*p*-MeC_6H_4CO	6	51	222	1604	$C_{17}H_{16}N_4O$	69.85	5.52	19.17
						(292.34)	69.56	5.29	18.85

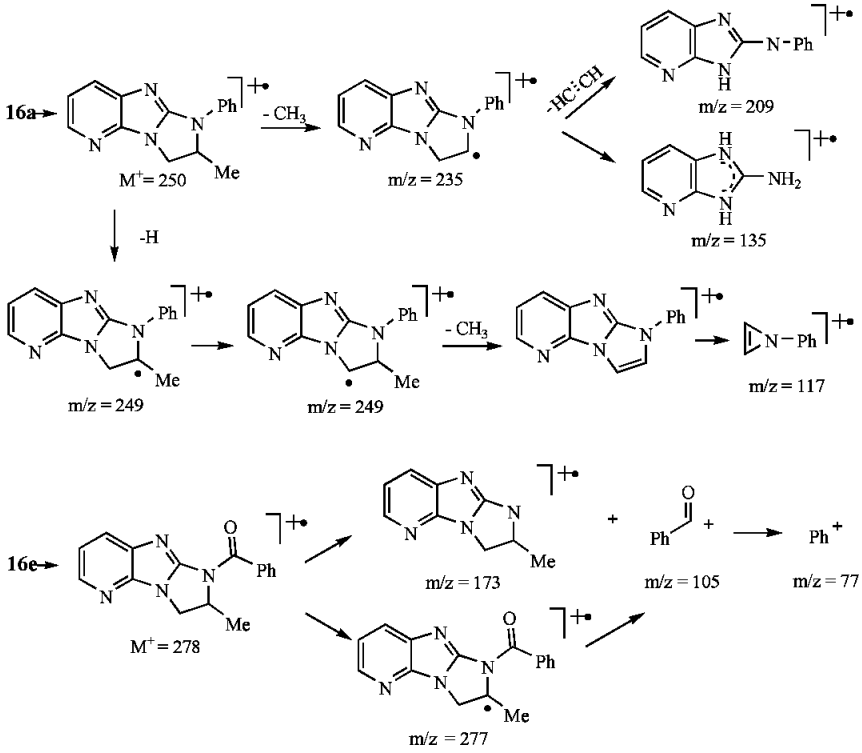
[a] Determined by using potassium bromide pellets.

[4,5-*b*]pyridines **16e-g** in yields of 51-64% under similar conditions. Possible compounds **18** were not observed. The results are listed in Table 2.

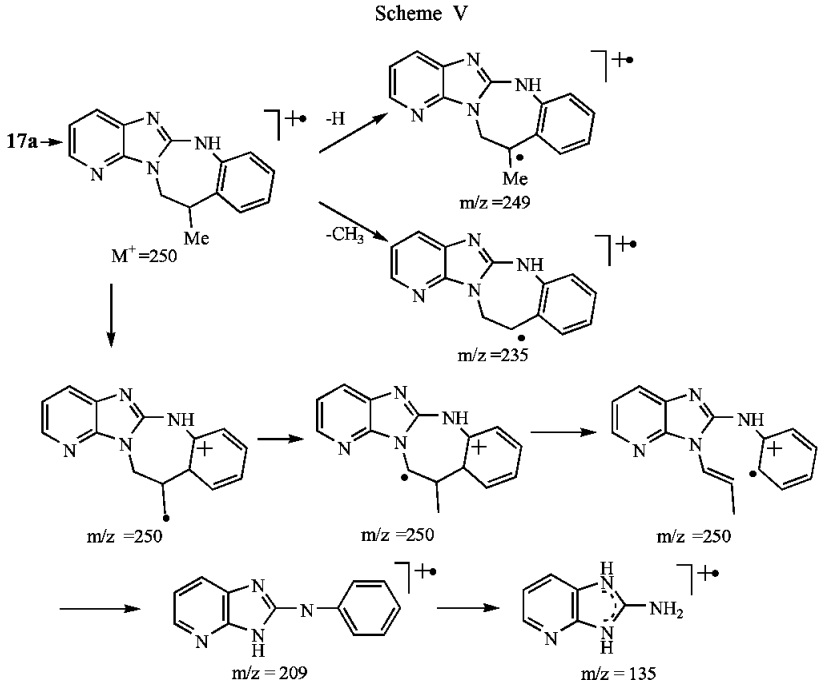
The structures **16** and **17** were assigned on the basis of spectroscopic data. Compound **16a**, for instance, had the molecular formula of $C_{15}H_{14}N_4$, as indicated by mass spectra (M^+ 250) as a base peak. The mass spectral data showed decomposition peaks at m/z = 249, 235, 209, 135 and 117. The proposed decomposition pathway is depicted in Scheme IV. In the ^1H nmr spectrum of **16a**, the signals from the two C3 hydrogens appear as two doublet of doublets at 4.27 (*J* = 15.3 and 8.1 Hz) and 4.51 ppm (*J* = 15.3 and 3.4 Hz), which arise as a result of coupling of the nonequivalent geminal hydrogens with one another and of each of them with the C2 hydrogen. The signal corresponding to the C2 hydrogen appears as a complex multiplet at 4.60 ppm, which arises from coupling with one of the C3 hydrogen atoms and the C2 methyl group. The ^{13}C nmr showed thirteen absorption peaks and its infrared spectrum showed no absorption in the region near 3400 cm^{-1}. Similarly, *N*-benzoyl compound **16e** had the molecular formula of $C_{16}H_{14}N_4O$, as indicated by mass spectra (M^+ 278) as 33% relative intensity. The mass spectral data showed characteristic decomposition peaks at m/z = 277, 173, 105 and 77. The benzoyl group is lost in the first step as a base peak and the other fragment (m/z = 173) which might be supported evidence of basic structure of 2,3-dihydro-1*H*-imidazo[2',3':2,3]imidazo[4,5-*b*]pyridines **16**. The proposed decomposition pathway is shown in Scheme IV. The ^1H nmr signals for the CH_2 (δ 4.48, dd, *J* = 13.7, 6.3 Hz and δ 4.67, dd, *J* = 13.7, 7.9 Hz) and CH (δ 4.85, m) groups were shifted slightly downfield. The ^{13}C nmr spectra revealed fourteen absorption signals including amide carbonyl absorption (δ 174.2). Its infrared spectrum showed absorption for amide carbonyl group (1631 cm^{-1}). Compound **17a** had the molecular formula of $C_{15}H_{14}N_4$, as indicated by mass spectra (M^+ 250) as a base peak again. The mass spectral data showed very similar decomposition peaks at m/z = 249, 235, 209 and 135 except 117 compared with those of **16a**. The proposed decomposition pathway is depicted in Scheme V. Comparison of the ^1H nmr signals for the CH_2 (δ 4.05, dd, *J* = 9.8, 4.0 Hz and δ 4.49, dd, *J* = 9.8, 8.5 Hz) and CH (δ 5.11, m) groups with those of **16a** showed different coupling constants (15.3 vs 9.8). Unfortunately, no N-H proton was observed distinctly. Possibility of decrease of integral in the aromatic region in a deuterium exchange experiment was fruitless. However the ^{13}C nmr exhibited fifteen absorption peaks and its infrared spectrum showed absorption for NH band (3440 cm^{-1}). These are supporting evidences that its structure assignment is correct.

In conclusion, using 2-(2-methylaziridin-1-yl)-3-ureidopyridines **12** in the synthesis of new pyridine-fused

Scheme IV



Scheme V



heterocycles *via* intramolecular cycloaddition reaction using Appel's conditions was achieved. Further experimental investigation of the synthetic possibilities of this kind of reactions in other heterocyclic systems is currently under way.

EXPERIMENTAL

All reagents and solvents were reagent grade or were purified by standard methods before use and the reactions were routinely carried out under an inert atmosphere. Silica gel 60 (70-230 mesh ASTM) used for column chromatography was supplied by E.

Table 3

^{1}H NMR Data of Compounds **12**, **16** and **17**

12a	1.19 (d, 3H, J = 5.2 Hz), 2.02 (m, 1H), 2.52 (m, 2H), 6.97-7.01 (m, 1H), 7.12-7.18 (m, 1H), 7.32-7.39 (m, 4H), 7.68 (s, 1H), 7.91-7.93 (m, 1H), 8.02 (s, 1H), 8.39-8.42 (m, 1H)
12b	1.26 (d, 3H, J = 4.9 Hz), 2.11 (m, 1H), 2.56 (m, 2H), 6.98-7.03 (m, 1H), 7.28-7.30 (m, 4H), 7.77 (s, 1H), 7.94-7.96 (m, 1H), 8.11 (s, 1H), 8.31-8.34 (m, 1H)
12c	1.29 (d, 3H, J = 5.2 Hz), 2.11 (m, 1H), 2.57 (m, 2H), 6.98-7.17 (m, 4H), 7.39 (s, 1H), 7.93-7.99 (m, 2H), 8.01 (s, 1H), 8.35-8.38 (m, 1H)
12d	1.17 (d, 3H, J = 5.2 Hz), 2.02 (m, 1H), 2.50 (m, 2H), 3.83 (s, 3H), 6.91(d, 2H, J = 8.9 Hz), 6.98-7.02 (m, 1H), 7.29 (d, 2H, J = 8.9 Hz), 7.52 (s, 1H), 7.91-7.93 (m, 1H), 8.04 (s, 1H), 8.45-8.48 (m, 1H)
12e	1.42 (d, 3H, J = 5.5 Hz), 2.41 (d, 1H, J = 4.0 Hz), 2.50 (d, 1H, J = 6.4 Hz), 2.77 (m, 1H), 6.98-7.02 (m, 1H), 7.51-7.65 (m, 3H), 7.99-8.03 (m, 3H), 8.51-8.53 (m, 1H), 9.16 (s, 1H), 11.46 (s, 1H)
12f	1.41 (d, 3H, J = 5.5 Hz), 2.40 (d, 1H, J = 4.0 Hz), 2.51 (d, 1H, J = 6.4 Hz), 6.99-7.03 (m, 1H), 7.47-7.51 (m, 2H), 8.01-8.05 (m, 3H), 8.44-8.47 (m, 1H), 9.97 (s, 1H), 11.50 (s, 1H)
12g	1.42 (d, 3H, J = 5.5 Hz), 2.41 (d, 1H, J = 4.0 Hz), 2.45 (s, 3H), 2.49 (d, 1H, J = 6.1 Hz), 2.77 (m, 1H), 6.97-7.01 (m, 1H), 7.32 (d, 2H, J = 8.0 Hz), 7.87 (d, 2H, J = 8.0 Hz), 8.00-8.02 (m, 1H), 8.51-8.54 (m, 1H), 8.87 (s, 1H), 11.43 (s, 1H)
16a	1.64 (d, 3H, J = 6.7 Hz), 4.27 (dd, 1H, J = 15.3 and 8.1 Hz), 4.51 (dd, 1H, J = 15.3 and 3.4 Hz), 4.60 (m, 1H), 7.01-7.12 (m, 2H), 7.29-7.35 (m, 2H), 7.56-7.58 (m, 2H), 7.74-7.76 (m, 1H), 8.08-8.10 (m, 1H)
16b	1.62 (d, 3H, J = 6.7 Hz), 4.25 (dd, 1H, J = 15.3 and 8.2 Hz), 4.50 (dd, 1H, J = 15.3 and 3.4 Hz), 4.59 (m, 1H), 7.09-7.13 (m, 1H), 7.24 (d, 2H, J = 8.9 Hz), 7.50 (d, 2H, J = 8.9 Hz), 7.73-7.75 (m, 1H), 8.10-8.12 (m, 1H)
16c	1.70 (d, 3H, J = 6.7 Hz), 4.29 (dd, 1H, J = 15.3 and 8.4 Hz), 4.58 (dd, 1H, J = 15.3 and 3.0 Hz), 4.67 (m, 1H), 6.98-7.21 (m, 3H), 7.39 (s, 1H), 7.78-7.81 (m, 1H), 8.12-8.14 (m, 1H), 8.37-8.43 (m, 1H)
16d	1.70 (d, 3H, J = 6.7 Hz), 3.81 (s, 3H), 4.27 (dd, 1H, J = 15.3 and 8.2 Hz), 4.56 (dd, 1H, J = 15.3 and 3.1 Hz), 4.66 (m, 1H), 6.93 (d, 2H, J = 8.9 Hz), 7.07-7.12 (m, 1H), 7.48 (d, 2H, J = 8.9 Hz), 7.72-7.75 (m, 1H), 8.06-8.08 (m, 1H)
16e	1.65 (d, 3H, J = 6.7 Hz), 4.48 (dd, 1H, J = 13.7 and 6.3 Hz), 4.67 (dd, 1H, J = 13.7 and 7.9 Hz), 4.85 (m, 1H), 7.14-7.18 (m, 1H), 7.43-7.55 (m, 4H), 8.26-8.35 (m, 3H)
16f	1.65 (d, 3H, J = 6.7 Hz), 4.46 (dd, 1H, J = 13.7 and 6.3 Hz), 4.66 (dd, 1H, J = 13.7 and 7.9 Hz), 4.82 (m, 1H), 7.17-7.21 (m, 1H), 7.41-7.55 (m, 3H), 8.24-8.29 (m, 3H)
16g	1.64 (d, 3H, J = 6.4 Hz), 2.43 (s, 3H), 4.47 (dd, 1H, J = 13.7 and 6.4 Hz), 4.66 (dd, 1H, J = 13.7 and 7.6 Hz), 4.84 (m, 1H), 7.15-7.28 (m, 3H), 7.52-7.54 (m, 1H), 8.20-8.27 (m, 3H)
17a	1.58 (d, 3H, J = 6.1 Hz), 4.05 (dd, 1H, J = 9.8 and 4.0 Hz), 4.49 (dd, 1H, J = 9.8 and 8.5 Hz), 5.11 (m, 1H), 7.04-7.12 (m, 2H), 7.40-7.74 (m, 4H), 8.04-8.06 (m, 1H)
17b	1.53 (d, 3H, J = 6.4 Hz), 4.02 (dd, 1H, J = 10.0 and 3.7 Hz), 4.44 (dd, 1H, J = 10.0 and 8.8 Hz), 5.03 (m, 1H), 7.04-7.08 (m, 1H), 7.30-7.73 (m, 4H), 8.04-8.06 (m, 1H)
17c	1.43 (d, 3H, J = 6.4 Hz), 4.01 (dd, 1H, J = 10.1 and 5.6 Hz), 4.55 (dd, 1H, J = 10.1 and 8.5 Hz), 5.14 (m, 1H), 7.01-7.06 (m, 1H), 7.19-7.89 (m, 4H), 8.02-8.05 (m, 1H)
17d	1.53 (d, 3H, J = 6.1 Hz), 3.82 (s, 3H), 4.01 (dd, 1H, J = 9.8 and 4.9 Hz), 4.50 (dd, 1H, J = 9.8 and 8.5 Hz), 5.01 (m, 1H), 6.95-7.05 (m, 3H), 7.54-7.59 (m, 1H), 7.65-7.68 (m, 1H), 8.00-8.03 (m, 1H)

Table 4

^{13}C NMR and Mass Spectra Data of Compounds **16** and **17**

	^{13}C nmr δ(ppm) (Deuteriochloroform)	Mass spectra m/z (%)
16a	22.6, 49.5, 57.4, 118.2, 119.2, 123.1, 123.7, 129.2, 134.7, 139.0, 140.4, 147.4, 151.0	250 (M^+, 100), 249 (33), 235 (65), 209 (43), 135 (13), 117 (11)
16b	22.5, 49.4, 57.3, 118.3, 120.4, 123.7, 127.9, 129.0, 134.4, 137.6, 140.6, 147.1, 150.6	286 (M^+, 39), 285 (34), 284 (M^+, 100), 283 (29), 271 (23), 269 (64), 245 (9), 243 (27), 208 (38), 153 (11), 151 (15), 135 (37)
16c	22.6, 49.8, 57.4, 114.8 (d), 118.3, 120.1, 122.7, 124.1, 124.7 (d), 134.6, 140.8, 147.3, 150.2, 150.8, 154.1	268 (M^+, 100), 267 (21), 253 (44), 228 (54), 227 (29), 209 (47), 159 (12), 135 (12)
16d	22.5, 49.2, 55.4, 56.8, 114.0, 114.8, 121.6, 122.5, 131.9, 134.8, 140.6, 147.5, 152.1, 156.0	280 (M^+, 100), 279 (13), 265 (62), 250 (16), 239 (12), 147 (55), 135 (15)
16e	22.6, 47.8, 54.8, 118.8, 119.1, 122.7, 128.1, 128.9, 131.5, 137.7, 142.6, 142.9, 152.7, 174.2	278 (M^+, 33), 277 (60), 173 (35), 105 (100), 77 (46)
16f	22.5, 47.7, 54.4, 118.7, 122.6, 128.0, 130.6, 136.3, 138.0, 142.8, 151.2, 152.5, 167.6, 173.0	314 (M^+, 7), 313 (13), 312 (M^+, 23), 311 (30), 209 (7), 207 (16), 173 (32), 141 (34), 139 (100), 113 (10), 111 (29)
16g	21.6, 22.6, 48.2, 53.6, 117.7, 118.6, 122.0, 128.8, 129.4, 134.7, 142.3, 143.1, 143.3, 154.1, 177.4	292 (M^+, 35), 291 (59), 173 (28), 119 (100), 91 (43)
17a	19.4, 46.8, 59.1, 117.4, 117.8, 122.7, 123.7, 128.5, 129.4, 131.9, 138.0, 140.1, 140.8, 145.8, 157.0	250 (M^+, 100), 249 (29), 235 (44), 209 (29), 135 (11)
17b	19.1, 46.6, 59.0, 117.4, 118.5, 123.7, 127.3, 128.3, 129.2, 131.8, 136.5, 140.2, 140.5, 145.5, 156.3	286 (M^+, 33), 285 (27), 284 (M^+, 100), 283 (28), 271 (20), 269 (58), 243 (27), 208 (40), 135 (33)
17c	19.3, 47.1, 61.6, 116.8 (d), 117.3, 123.6, 125.0, 126.7, 127.2 (d), 128.4 (d), 132.0, 133.2, 139.9, 146.1, 154.7	268 (M^+, 100), 267 (14), 253 (40), 227 (15), 159 (12), 135 (10)
17d	19.1, 46.6, 55.4, 59.8, 114.6, 117.1, 120.5, 123.1, 128.3, 130.9, 131.9, 139.6, 140.8, 145.9, 155.7, 157.6	280 (M^+, 100), 279 (13), 265 (63), 250 (15), 147(52), 135 (15)

Merck. Analytical thin layer chromatography (tlc) was performed on silica gel with fluorescent indicator coated on aluminium sheets. Melting points were taken using an Electrothermal melting point apparatus and are uncorrected. Microanalyses were obtained using a Carlo Erba EA 1180 element analyzer. Mass spectra were obtained using a ThermoQuest Polaris Q mass spectrometer operating at 70 eV. Infrared spectra were recorded on a Nicolet Magna 550 FTIR spectrometer. The ^{1}H and ^{13}C nmr spectra were measured on a Gemini 300 spectrometer using deuteriochloroform. All chemical shifts are reported in parts per million (δ) relative to tetramethylsilane.

2-Chloro-3-nitropyridine and 2-methylaziridine were purchased from Aldrich Chemical Company.

2-(2-Methylaziridin-1-yl)-3-nitropyridine (**10**).

To a solution of 2-methylaziridine (1.42 g, 25 mmoles) and triethylamine (4.04 g, 40 mmoles) in 50 ml of tetrahydrofuran was added 2-chloro-3-nitropyridine (**9**, 3.17 g, 20 mmoles) and the mixture was stirred at room temperature for 8 hours. The solvent was removed on a rotavapor and the residue was partitioned between water (10 ml) and dichloromethane (30 ml). The dichloromethane layer was removed after drying over magnesium sulfate to give 3.36 g (94%) of **10**, red oil; ir (Nujol): 1600, 1651, 1518, 1429, 1343, 1254, 854, 772 cm^{-1}; ^{1}H nmr (deuteriochloroform): δ 1.45 (d, 3H, J = 5.2 Hz), 2.37 (d, 1H, J = 4.0 Hz), 2.63 (d, 1H, J = 6.1 Hz), 2.71 (m, 1H), 7.05-7.09 (m, 1H), 8.27-8.30 (m, 1H), 8.49-8.51 (m, 1H).

Anal. Calcd. for $C_8H_9N_3O_2$: C, 53.63; H, 5.06; N, 23.45. Found: C, 53.41; H, 4.85; N, 23.18.

3-Amino-2-(2-methylaziridin-1-yl)pyridine (**11**).

To a solution of 2-(2-methylaziridin-1-yl)-3-nitropyridine (**10**, 1.49 g, 10 mmoles) in 20 ml of tetrahydrofuran was added 5% palladium on charcoal (0.21 g, 0.1 mmoles) and the mixture was stirred under hydrogen at atmospheric pressure and room temperature for 12 hours. The reaction mixture was filtered over celite and the filtrate was evaporated *in vacuo* to give an oily residue. The residue was chromatographed on silica gel column and eluted with hexane-ethyl acetate 1:1 to give 1.22 g (82%) of **11**, mp 57-58°; ir (potassium bromide): 3351, 3192, 1642, 1584, 1448, 1266, 765 cm^{-1}; ^{1}H nmr (deuteriochloroform): δ 1.42 (d, 3H, J = 5.5 Hz), 2.11 (d, 1H, J = 3.7 Hz), 2.42 (m, 1H), 2.53 (d, 1H, J = 6.4 Hz), 3.92 (broad s, 2H), 6.78-6.82 (m, 1H), 6.90-6.93 (m, 1H), 7.68-7.70 (m, 1H).

Anal. Calcd. for $C_8H_{11}N_3$: C, 64.40; H, 7.43; N, 28.16. Found: C, 64.59; H, 7.25; N, 28.43.

2-(2-Methylaziridin-1-yl)-3-ureidopyridines **12**.

General Procedure.

To a stirred solution of 3-amino-2-(2-methylaziridin-1-yl)pyridine (**11**, 1.49 g, 10 mmoles) in 20 ml of dichloromethane was added the isocyanate (10 mmoles) at room temperature. After stirring for 2-4 hours at ambient temperature, the solvent was removed on a roto-evaporator. The residue was crystallized from hexane-ether to yield **12**.

The physical and spectral data of **12** prepared by this general method are listed in Table 1 and Table 3.

2,3-Dihydro-1*H*-imidazo[2',3':2,3]imidazo[4,5-*b*]pyridines **16** and 12,13-dihydro-5*H*-1,3-benzodiazepino[2',3':2,3]imidazo-[4,5-*b*]pyridines **17**.

General Procedure.

To a stirred solution of the appropriate urea **12** (3 mmoles) in 30 ml of dichloromethane was added triphenylphosphine (1.96 g, 7.5 mmoles), carbon tetrachloride (1.5 ml, 15 mmoles), and triethylamine (1.05 ml, 7.5 mmoles). The mixture was heated to reflux temperature for the time indicated in Table 2. After cooling to room temperature the reaction mixture was partitioned between water and dichloromethane (20 ml x 2). After drying over magnesium sulfate the solvent was removed and the residue was chromatographed on silica gel column, eluted with hexane-ethyl acetate 4:1 to yield the products **16** and **17** as white solids.

The physical and spectral data of **16** and **17** prepared by this general method are listed in Table 2, Table 3, and Table 4.

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