4-Diazomethylcoumarins and Related Stable Heteroaryldiazomethanes. Thermal Conversion into Condensed Pyrazoles [1]

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4-Diazomethyl-substituted coumarins, 1-methyl-2(1*H*)-quinolinones, 1-thiocoumarin and their tricyclic analogs were found to be easily cyclized into the corresponding pyrazole isomers condensed with heteroaromatics. Thermodependent feature of these conversions and the remarkably accelerating effect of the alkyl substituent peri to the diazomethyl group were realized. Some other diazomethyl compounds connected with 2-pyridinone, 3-pyrazolone, chromone and 1-thiochromone were prepared, and their stability and thermal properties were compared.

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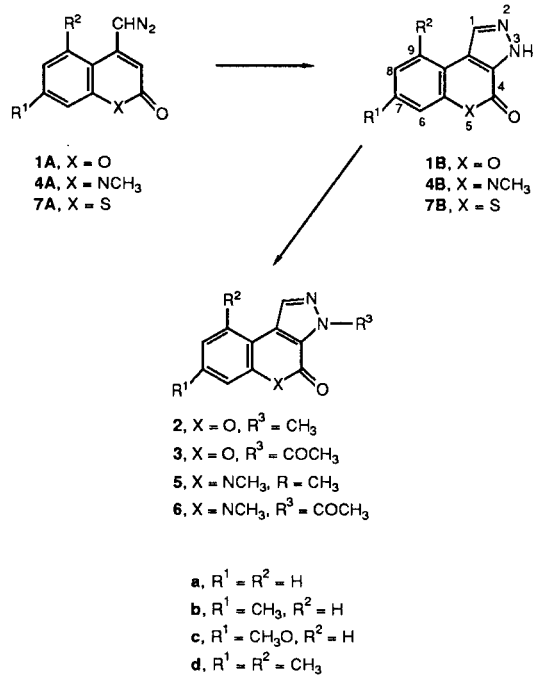
Numerous examples have been described so far [2a-c] on the role of diazoalkanes in organic synthesis as well as in biological application reflecting high reactivity of the diazo group, although troublesome handling due to instability, toxicity and explosive nature places some restrictions on the general use of diazoalkanes. Several heteroaryldiazomethanes, in which the diazomethyl group is connected with the coumarin (2*H*-1-benzopyran-2-one) and the isosteric 2(1*H*)-quinolinone nucleus, were recently developed in this laboratory [3-6] and other's [7] as a stable and practically useful fluorescent labelling reagent for acidic substances. During the course of our studies on the stability of this new type of compounds, we have noticed facile conversion of the 4-diazomethylcoumarins into the cyclized isomers on heating and this was reported as communication [8] as the first example of intramolecular diazomethyl cyclization into the pyrazoles condensed with heteroaromatic system. The present paper describes details of the thermal conversion of these diazomethylcoumarins along with that of the analogous 2(1*H*)-quinolinone and 1-thiocoumarin (2*H*-1-benzothiopyran-2-one) derivatives. Preparation and thermal properties of some related stable diazomethyl-substituted heteroaromatics are also reported.

The thermal conversion of 4-diazomethylcoumarins **1A** into benzopyrano[3,4-*c*]pyrazol-4(3*H*)-ones **1B** readily occurred when the yellow solution of **1A** was heated in toluene for a short period (within 10 minutes). Compound **1B** was obtained as a highly pure white precipitate in the solution in good yield (over 85%) after 60 minutes' refluxing (see Table 1).

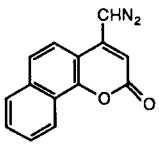
The condensed pyrazole structure of the representative **1aB** was confirmed as follows. Microanalysis and mass spectral data showed that **1aB** is an isomer of **1aA**. Fragmentation patterns of the two mass spectra were almost identical to each other. The characteristic diazomethyl ir absorption of **1aA** (ν_{KBr} 2082 cm^{-1}) disappeared, whereas the NH absorption (3282 cm^{-1}) appeared in **1aB**. In the



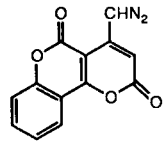
^{1}H-nmr spectrum of **1aB** (in DMSO-d_6) a new singlet signal of C^1-H (δ 8.63 ppm) and a broad singlet of NH proton (14.56 ppm, exchangeable with deuterium oxide) appeared instead of the diazomethyl H (5.90 ppm) and C^3-H (6.56 ppm) singlet signals in **1aA**. Also in the ^{13}C-nmr spectra high field signals of **1aA** attributable to diazomethyl C (δ 45.9 ppm) and C-3 (99.6 ppm) [4] disappeared in **1aB**. These spectral data are consistent with the assigned benzopyranopyrazole structure of **1aB**. Treatment of **1aB** with diazomethane at 0° and with acetic anhydride at 100° gave *N*-methyl and *N*-acetyl derivatives, **2a** and **3a**, respectively. Finally, the derived **2a** was shown to be identical in all aspects with the sample independently prepared from 3-toluenesulfonylcoumarin and diazomethane according to the previously reported method [9].

A similar pyrazole cyclization was observed with the

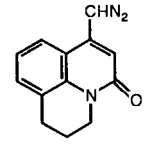
analogous stable diazomethyl derivatives connected with the coumarin isosteres, 1-methyl-2(1*H*)-quinolinones **4A** [6] and 1-thiocoumarin **7A**, and with the related tricyclic heteroaromatics **8A-11A** [5,6], recently reported from this laboratory. The conversions into the hitherto unknown cyclized isomers, **4B**, **7B** ~ **11B**, were successfully achieved, again in refluxing toluene in good yields, as summarized in Table 1. The conversion of **7aA** occurred even in refluxing chloroform. Thus, the reactivity among the isosteric **1aA**, **4aA** and **7aA** seems to increase in the order of X = NCH_3 < O < S (see Table 1).



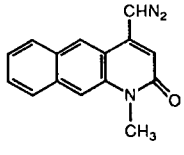
8A



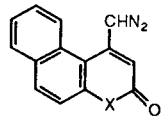
9A



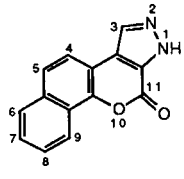
10A



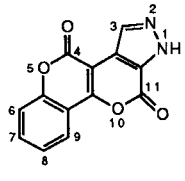
11A



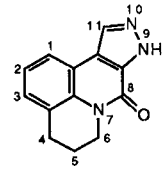
12A, (X = O)
13A, (X = NCH_3)



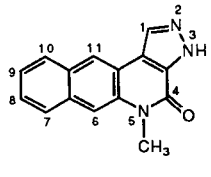
8B



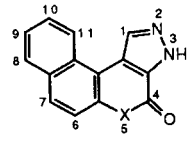
9B



10B



11B



12B, (X = O)
13B, (X = NCH_3)

As for the conversion of **1aA** into **1aB**, the reaction proceeded rapidly at 100° or above, but never below 70° irrespective of the solvent used, as shown in Table 2, suggesting thermo-dependence of this type of cyclization. Another characteristic feature concerning the conversion of **1A** and **4A** is that the presence of the alkyl substituent at the position peri to the attached diazomethyl group in the heteroaromatics markedly destabilizes the diazo structure and facilitates the pyrazole isomerization. Thus, the cyclization of 5,7-dimethyl derivatives, **1dA**,**4dA** [6], and of 5,6-benzo-fused derivatives, **12A** [5], **13A** [6], could be more readily achieved in refluxing chloroform (Table 3),

Table 1

Thermal Isomerization [a] of 4-Diazomethyl-substituted Coumarins and Related Heteroaromatics

Compound	Solvent	Reaction Time (hour)	Yield (%) of Product [b]
1aA	Toluene	1	85
1aA	Chloroform	3	0 [c]
1bA	Toluene	1	91
1cA	Toluene	1	90
4aA	Toluene	3	68
4aA	Chloroform	3	0 [c]
4bA	Toluene	3	74
4cA	Toluene	3	79
7aA	Toluene	1/4	92
7aA	Chloroform	3	90
8A	Toluene	1	88
9A	Toluene	1	89
10A	Toluene	3	55
11A	Toluene	3	80

[a] Carried out on reflux. [b] Isolated yield of **B** series. [c] No reaction occurred.

Table 2

Effect of Solvent and Temperature on the Thermal Isomerization of **1aA** into **1aB**

Solvent	Reaction Temperature (°C)	Reaction Time (hour)	Yield [a] (%)
Toluene	Refluxing	1	85
Toluene	100	3	86
Toluene	90	6	80
Toluene	60	10	0 [b]
Chloroform	Refluxing	10	0 [b]
Dioxane	100	3	86
Dioxane	90	8	64
DMF	100	3	80
Butanol	100	3	76
Butanol	90	8	61
Pyridine	100	3	79
none	120 ~ 130	2	84

[a] Isolated yield of **1aB**. [b] No change of **1aA** was observed on tlc.

while the corresponding 5-unsubstituted **1bA**, **4bA** or **1aA**, **4aA** did not isomerize at all in the same solvent. 1-Diazomethyl-3*H*-naphtho[2,1-*b*]pyran-3-one **12A** was unstable enough to be isomerized almost instantaneously at 100° in toluene and gradually on standing in chloroform even at room temperature. A similar facile cyclization caused by the peri substituent was reported [10] for the

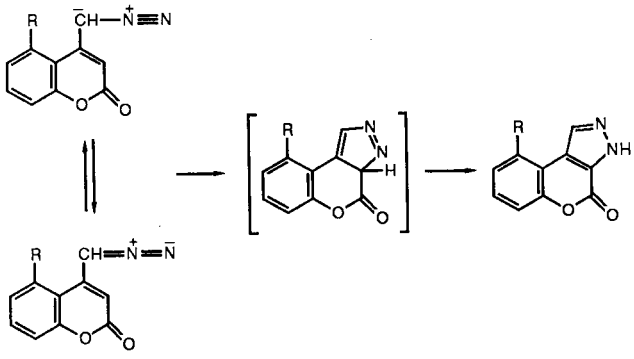
Table 3

Peri Substituent Effect on the Thermal Isomerization

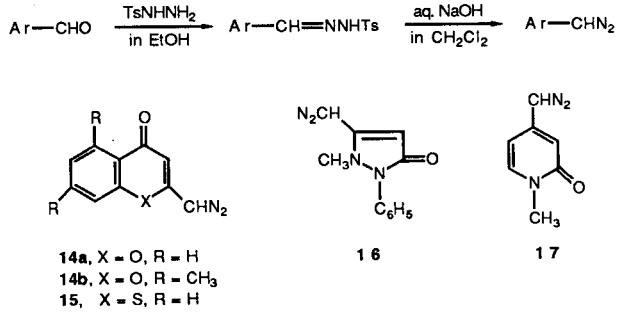
Compound	Solvent	Reaction Temperature (°C)	Reaction Time (hour)	Yield (%) of Product [a]	Reference Compound
1dA	Chloroform	Refluxing	0.5	82	**1bA** [b]
12A	Chloroform	Refluxing	0.5	85	**1aA** [b]
12A	Chloroform	24	24	73	**1aA** [b]
12A	Toluene	100	3 min	96	**1aA** [c]
4dA	Chloroform	Refluxing	2	94	**4bA** [b]
13A	Chloroform	Refluxing	3	87	**4aA** [b]

[a] Isolated yield. [b] No reaction occurred in chloroform on reflux. [c] The reaction in toluene at 100° needed 3 hours to attain 86% yield (see Table 2).

isomerization of (8-bromo-1-naphthyl)diazomethane into 9-bromo-3*H*-benzo[*e*]indazole. From those features of the reaction described above, the present conversion of heteroaryldiazomethanes is supposed to involve thermally induced 1,5-electrocyclic type of ring closure reaction [11a-c] followed by proton migration to afford the hetaro-condensed pyrazole isomers. The vinylogous diazoketone structure like **1A**, **4A** or **7A** is not necessarily unstable as such, but the presence of the bulky alkyl substituent at the peri position seems responsible for easy attack of the terminal diazo nitrogen at the reactive C-3 position leading to the formation of more stable aromatic system, rather than decomposition through nitrogen elimination.



Some other diazomethyl compounds connected with the related heteroaromatics such as 2(1*H*)-pyridinone, 3*H*-pyrazol-3-one, chromone (4*H*-1-benzopyran-4-one) or 1-thiochromone (4*H*-1-benzothoipyran-4-one) were next prepared for comparison of the stability and reactivity. These diazomethyl compounds were readily obtained from the corresponding heteroaromatic carboxyaldehydes by the procedure generally applied for the preparation of **4A**, *ie.*, the Bamford-Stevens reaction [12] of aldehyde tosylhydrazones by the use of 0.2 *N* sodium hydroxide according to Cava's method [13].



14a, X = O, R = H
14b, X = O, R = CH_3
15, X = S, R = H

16

17

Similarly to **1A**, **4A**, and **7A ~ 13A**, the prepared diazo compounds **14 ~ 17** are colored crystals, the diazo structure of which was characterized by their ir and ^{1}H-nmr spectra. They were stable enough to be stored at room temperature without decomposition, but were found to be changeable on heating. However, refluxing of **14 ~ 16** in toluene or benzene effected no isomerization but afforded a mixture of several oily products, structures of which could not yet be identified, whereas in refluxing chloroform they did not suffer any change. On the other hand, 4-diazomethyl-1-methyl-2(1*H*)-pyridinone **17**, although stable in chloroform at reflux, was shown to be converted into 1-methyl-2(1*H*)-pyridinone-4-carboxyaldehyde azine **18** in refluxing toluene. The structure of **18** was ascertained by comparison with the authentic sample. Examples of azine formation from diazomethyl compound are known [14].

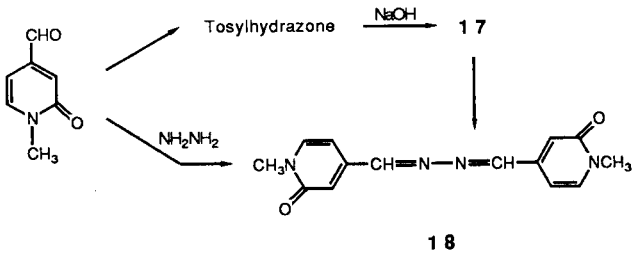


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Table 4

Physical, Spectral and Analytical Data of **1B**, **4B** and **7B**~**13B** [a]

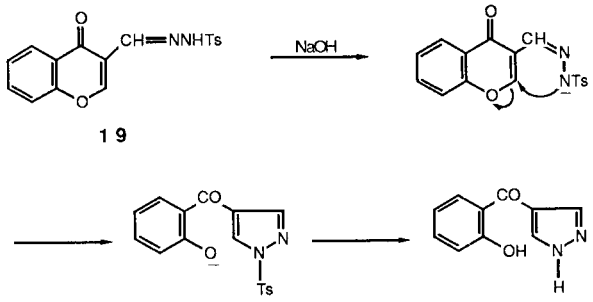
Compound	Appearance (Recrystallization Solvent) [b]	Formula (M^+)	Analysis Calcd./(Found) C	H	N	IR cm^{-1} (Potassium Bromide) NH	CO	^{1}H-NMR (DMSO-d_6) δ ppm [c]
1aB	Needles (A)	$C_{10}H_6N_2O_2$ (186)	64.51 (64.61)	3.25 (3.14)	15.05 (15.22)	3282	1726	7.28~7.40 (3H, m, $C^{6\sim8}$-H), 7.94 (1H, d, $J_{8,9}$ = 5.4 Hz, C^9-H), 8.63 (1H, s, C^1-H), 14.56 (1H, br s, NH)
1bB	Leaves (A)	$C_{11}H_8N_2O_2$ (200)	65.99 (65.90)	4.03 (4.05)	13.99 (14.06)	3298	1727	2.36 (3H, s, CH_3), 7.15 (1H, d, $J_{8,9}$ = 8.8 Hz, C^8-H), 7.20 (1H, s, C^6-H), 7.80 (1H, d, $J_{8,9}$ = 8.8 Hz, C^9-H), 8.56 (1H, s, C^1-H), 14.50 (1H, br s, NH)
1cB	Pale yellow needles (B)	$C_{11}H_8N_2O_3$ (216)	61.11 (61.20)	3.73 (3.67)	12.96 (12.98)	3284	1723	3.82 (3H, s, CH_3O), 6.96 (1H, d, $J_{8,9}$ = 8.3 Hz, C^8-H), 7.01 (1H, s, C^6-H), 7.86 (1H, d, $J_{8,9}$ = 8.3 Hz, C^9-H), 8.52 (1H, s, C^1-H), 14.45 (1H, br s, NH)
1dB	Prisms (C)	$C_{12}H_{10}N_2O_2$ (214)	67.28 (67.22)	4.71 (4.81)	13.08 (13.37)	3150	1707	2.35, 2.55 (3H × 2, s × 2, CH_3), 7.03, 7.07 (1H × 2, s × 2, C^6-H, C^8-H), 8.47 (1H, s, C^1-H), 14.64 (1H, br s, NH)
8B	Prisms (C)	$C_{14}H_8N_2O_2$ (236)	71.18 (71.46)	3.41 (3.67)	11.86 (11.65)	3294	1730	7.61~8.10 (5H, m, $C^{4\sim8}$-H), 8.34 (1H, $J_{8,9}$ = 8.1 Hz, C^9-H), 8.75 (1H, s, C^3-H), 14.65 (1H, br s, NH)
9B	Pale yellow prisms (A)	$C_{13}H_6N_2O_4$ (254)	61.42 (61.38)	2.38 (2.37)	11.02 (10.80)	3294	1720 1762	7.38~7.80 (3H, m, $C^{6\sim8}$-H), 7.96 (1H, d, $J_{8,9}$ = 8.8 Hz, C^9-H), 8.48 (1H, s, C^3-H), 14.75 (1H, br s, NH)
12B	Needles (A)	$C_{14}H_8N_2O_2$ (236)	71.18 (71.15)	3.41 (3.41)	11.86 (11.66)	3098	1764	7.53~8.04 (5H, m, $C^{6\sim10}$-H), 8.61 (1H, d, $J_{10,11}$ = 8.1 Hz, C^{11}-H), 9.25 (1H, s, C^1-H), 14.82 (1H, br s, NH)
4aB	Pale yellow prisms (D)	$C_{11}H_9N_3O$ (199)	66.31 (66.55)	4.55 (4.69)	21.10 (21.41)	3143	1639	3.69 (3H, s, CH_3), 7.30~7.53 (3H, m, $C^{6\sim8}$-H), 8.06 (1H, d, $J_{8,9}$ = 7.8 Hz, C^9-H), 8.45 (1H, s, C^1-H), 14.30 (1H, br s, NH)
4bB	Yellow prisms (C)	$C_{12}H_{11}N_3O$ (213)	67.59 (67.77)	5.20 (5.21)	19.71 (19.52)	3118	1619	2.46 (3H, s, C^7-CH_3), 3.69 (3H, s, N-CH_3), 7.16 (1H, d, $J_{8,9}$ = 7.3 Hz, C^8-H), 7.40 (1H, s, C^6-H), 7.96 (1H, d, $J_{8,9}$ = 7.5 Hz, C^9-H), 8.43 (1H, s, C^1-H), 14.22 (1H, br s, NH)
4cB	Yellow prisms (A)	$C_{12}H_{11}N_3O_2$ (229)	62.87 (62.59)	4.84 (4.78)	18.33 (18.50)	3166	1658	3.70, 3.88 (3H × 2, s × 2, N-CH_3, O-CH_3), 6.95~7.03 (2H, m, $C^{6,8}$-H), 8.01 (1H, d, $J_{8,9}$ = 8.3 Hz, C^9-H), 8.37 (1H, s, C^1-H), 14.19 (1H, br s, NH)
4dB	Yellow prisms (C)	$C_{13}H_{13}N_3O$ (227)	68.70 (68.79)	5.77 (5.74)	18.49 (18.57)	3139	1644	2.41 (3H, s, C^7-CH_3), 2.64 (3H,s, C^9-CH_3), 3.68 (3H, s, N-CH_3), 7.01 (1H, s, C^8-H), 7.25 (1H, s, C^6-H), 8.29 (1H, s, C^1-H), 14.35 (1H, br s, NH)
10B	Yellow prisms (A)	$C_{13}H_{11}N_3O$ (225)	69.32 (69.48)	4.92 (4.83)	18.66 (18.98)	3130	1636	2.01 (2H, m, C^5-H), 2.95 (2H, t, $J_{4,5}$ = 5.8 Hz, C^4-H), 4.17 (2H, t, $J_{5,6}$ = 5.7 Hz, C^6-H), 7.10~7.24 (2H, m, $C^{2,3}$-H), 7.88 (1H, m, C^1-H), 8.44 (1H, s, C^{11}-H), 14.25 (1H, br s, NH)
11B	Pale pink prisms (A)	$C_{15}H_{11}N_3O$ (249)	72.27 (72.24)	4.45 (4.39)	16.86 (16.70)	3158	1655	3.77 (3H, s, CH_3), 7.47~8.01 (5H, m, $C^{6\sim10}$-H), 8.55, 8.63 (1H, × 2, s × 2, C^1-H, C^{11}-H), 14.40 (1H, br s, NH)
13B	Yellow prisms (C)	$C_{15}H_{11}N_3O$ (249)	72.27 (72.39)	4.45 (4.39)	16.86 (16.91)	3128	1637	3.88 (3H, s, CH_3), 7.52~8.14 (5H, m, $C^{6\sim10}$-H), 8.80 (1H, d, $J_{10,11}$ = 7.8 Hz, C^{11}-H), 9.00 (1H, s, C^1-H), 14.56 (1H, br s, NH)
7B [d]	Prisms (A)	$C_{10}H_6N_2OS$ (202)	59.39 (59.28)	2.99 (2.97)	13.85 (13.66)	3238	1620	7.43~8.32 (4H, m, $C^{6\sim9}$-H), 8.67 (1H, s, C^1-H), 14.60 (1H, br s, NH)

[a] Mp >250° for all compounds. [b] A, Dioxane; B, Tetrahydrofuran; C, *N,N*-Dimethylformamide; D, 2-Propanol. [c] For the numbering of the compounds, refer to the text. [d] Microanalysis of S: Calcd. 15.85; Found 15.60.

Thus, the facile isomerization of the diazo **A** series into the condensed pyrazole **B** series as described in this paper appears to be caused by pecularity of the structure, in which the diazomethyl substituent is linked at the favorable position to attack the reactive site of the heteroaromatic ring resulting in cyclization. The reaction can be regarded as the final stage of the convenient route to the hetaro-condensed pyrazoles **1B**, **4B** and **7B** starting from the readily available heteroaromatics bearing a suitable methyl substituent, which is capable of being oxidized into carboxyaldehyde with selenium dioxide [15] followed by conversion into the diazomethyl functionality. It is noteworthy that the isomeric [4,3-*c*]-condensed benzopyranopyrazolones and pyrazoloquinolinones wer recently report-

ed [16a-b] to have affinity for the benzodiazepine drug receptors.

An attempt to prepare 3-diazomethylchromone was unsuccessful, since usual treatment of chromone-3-carboxaldehyde tosylhydrazone **19** with dilute sodium hydroxide solution at room temperature did not lead to the diazo compound, but afforded 4-(2-hydroxybenzoyl)-1*H*-pyrazole **20**, in 66% yield. Formation of **20** from **19** is supposed to be caused by preferential attack of the base-induced tosylhydrazone anion at the reactive C-2 position of chromone with concomitant ring opening and detosylatin. Similar formation of **20** from chromone-3-carboxaldehyde by the action of hydrazine was already reported [17a-b].



EXPERIMENTAL

All melting points were determined with a Yanaco micro melting point apparatus and are uncorrected. The ir spectra [ν max (potassium bromide) cm^{-1}] were determined using a Hitachi 215 grating spectrophotometer. The uv spectra [λ max nm ($\epsilon \times 10^{-3}$)] were obtained with a Hitachi 200-10 spectrophotometer. Mass spectra [m/e (relative intensity), direct inlet at 70eV] were taken on a Shimadzu LKB-900B spectrometer. The ^1H- and ^{13}C-nmr spectra (δ ppm) were recorded with a JEOL JNM FX-100 or JNM GX-270 spectrometer, using tetramethylsilane as an internal standard. 4-Diazomethylcoumarins, **1aA ~ 1cA**, **8A**, **9A** and **12A** [3-5], and 4-diazomethyl-1-methyl-2(1*H*)-quinolinones, **4aA ~ 4dA**, **10A**, **11A** and **13A** [6], were prepared as reported.

4-Diazomethyl-1-thiocoumarin (**7aA**).

Into a solution of 4-formyl-1-thiocoumarin [15] (760 mg, 4 mmoles) in ethanol (10 ml) was added tosylhydrazide (819 mg, 4.4 mmoles), and the whole was stirred at room temperature whereupon white precipitate appeared in the solution. After 7 hours the precipitate was collected, washed with a small amount of ethanol and dried to afford tosylhydrazone (1.21 g, 93%) in almost pure state. The obtained tosylhydrazone (274 mg, 0.84 mmole) was suspended in dichloromethane (12 ml), and 0.2 *N* sodium hydroxide (12.5 ml) was added dropwise at 10°. The mixture was vigorously stirred at room temperature for 8 hours, then the organic layer was separated, washed with cold water, dried over anhydrous magnesium sulfate, and evaporated to dryness. Recrystallization of the residue from carbon tetrachloride gave 125 mg (74%) of **7aA** as yellow prisms. They did not show any distinct melting point, but changed into white crystals, mp >250°; ir (potassium bromide): 2072 (N_2), 1597 (CO); ms: 202 (M^+, 100); ^1H-nmr (deuteriochloroform): 5.47 (1H, s, CHN_2), 6.25 (1H, s, C^3-H), 7.36 ~ 7.56 (4H, m, $C^{5\sim8}$-H).

Anal. Calcd. for $C_{10}H_6N_2OS$: C, 59.39; H, 2.99; N, 13.85; S, 15.85. Found: C, 59.29; H, 2.91; N, 13.81; S, 15.63.

4-Diazomethyl-5,7-dimethylcoumarin (**1dA**).

4-Formyl-5,7-dimethylcoumarin, prisms from benzene, mp 165-166°, was prepared by selenium dioxide oxidation of 4,5,7-trimethylcoumarin [18] according to the reported procedure [15]; ^1H-nmr (deuteriochloroform): 2.42 and 2.52 (3H × 2, s × 2, CH_3 × 2), 6.48 (1H, s, C^3-H), 6.98 and 7.05 (1H × 2, s × 2, C^6-H, C^8-H), 10.49 (1H, s, CHO).

Anal. Calcd. for $C_{12}H_{10}O_3$: C, 71.28; H, 4.99. Found: C, 71.00; H, 4.97.

4-Formyl-5,7-dimethylcoumarin was converted into tosylhydrazone as described above. The obtained tosylhydrazone (1.11 g, 3 mmoles), without recrystallization, was suspended in methanol (8 ml) and added in a portion with triethylamine (0.3 g, 3 mmoles) in methanol (2 ml) on ice-cooling. After stirring for 2 hours in an ice bath and then for 1 hour at room temperature, the resulting yellow precipitate was collected by filtration and dried to give **1dA**, 590 mg (92%). The obtained prisms did not show any distinct melting point, but gradually changed into white crystals, mp >250°; ir (potassium bromide): 2074 (N_2), 1689 (CO); ms: 214 (M^+, 100); ^1H-nmr (deuteriochloroform): 2.36 and 2.65 (3H × 2, s × 2, CH_3 × 2), 5.77 (1H, s, CHN_2), 5.80 (1H, s, C^3-H), 6.85 and 6.99 (1H × 2, s × 2, C^6-H, C^8-H).

Anal. Calcd. for $C_{12}H_{10}N_2O_2$: C, 67.28; H, 4.71; N, 13.08. Found: C, 67.38; H, 4.69; N, 13.04.

Isomerization of Heteroaryldiazomethanes. Typical Procedure.

4-Diazomethylcoumarin **1aA** (1.86 g, 10 mmoles) was added in toluene (30 ml) and the mixture was heated with stirring. Refluxing the mixture resulted in rapid dissolution, followed by sudden appearance of a white precipitate in the yellow solution within 5 minutes. After refluxing for 1 hour with stirring, the precipitate was collected on cooling by filtration, washed with ether and dried to give 1.58 g (85%) of benzopyrano[3,4-*c*]-pyrazol-4(3*H*)-one **1aB**, needles from dioxane, mp >270°; uv (ethanol): 256 (10.4), 294.5 (9.1); ^{13}C-nmr (DMSO-d_6): d 116.82, 123.96, 124.57, 128.25, 150.60; s 115.75; four singlets not observed. The ir, ms, ^1H-nmr spectral and microanalytical data are recorded in Table 4.

A similar procedure was followed for the other heteroaryldiazomethanes, **1A**, **4A**, **7A ~ 13A**, among which **4dA**, **11A** and **13A** were insoluble in refluxing toluene.

N-Methylation of Compounds **1aB** and **4aB**.

Compound **1aB** (390 mg, 2.01 mmoles) was added in a portion into an etheral solution (50 ml) of excess diazomethane with stirring in an ice bath. After stirring for 4 hours in an ice bath and then for 4 hours at room temperature, the precipitate was collected and dried to give 409 mg (98%) of 3-methylbenzopyrano[3,4-*c*]pyrazol-4(3*H*)-one **2a**, needles from 2-propanol, mp 163-164° (lit [9] mp 160-162°); ir (potassium bromide): 1726 (CO); uv (ethanol): 225.5 (19.4), 259 (5.8), 300.5 (9.3); ms: 200 (M^+, 100); ^1H-nmr (DMSO-d_6): 4.23 (3H, s, CH_3), 7.38 ~ 7.47 (3H, m, $C^{6\sim8}$-H), 8.01 (1H, d, $J_{8,9}$ = 7.6 Hz, C^9-H), 8.40 (1H, s, C^1-H); ^{13}C-nmr (deuteriochloroform): q 38.84, d 117.25, 123.19, 124.80, 128.55, 131.81; s, 115.69, 124.36, 125.09, 151.16, 153.79.

Anal. Calcd. for $C_{11}H_8N_2O_2$: C, 65.99; H, 4.03; N, 13.99. Found: C, 66.13; H, 3.90; N, 13.98.

A similar treatment of compound **4aB** with diazomethane gave a 90% yield of 3,5-dihydro-3,5-dimethylpyrazolo[3,4-*c*]quinolin-4-one **5a**, yellow prisms from 2-propanol, mp 185-187°; ir (potassium bromide) 1658 (CO); ms: 213 (M^+, 100); ^1H-nmr (DMSO-d_6): 3.64 (3H, s, N^5-CH_3), 4.28 (3H, s, N^3-CH_3), 7.28 ~ 7.53 (3H, m, $C^{6\sim8}$-H), 8.02 (1H, d, $J_{8,9}$ = 8.3 Hz, C^9-H), 8.36 (1H, s, C^1-H).

Anal. Calcd. for $C_{12}H_{11}N_3O$: C, 67.59; H, 5.20; N, 19.71. Found: C, 67.54; H, 5.26; N, 19.44.

N-Acetylation of Compounds **1aB** and **4aB**.

A mixture of compound **1aB** (400 mg, 2.15 mmoles) and acetic anhydride (3 ml) was heated at 120° for 4 hours. After cooling, the precipitate was collected, washed well with water and dried to give 441 mg (90%) of 3-acetylbenzopyrano[3,4-*c*]pyrazol-4(3*H*)-one **3a**, prisms from DMF, mp >250°; ir (potassium bromide): 1773 and 1752 (CO); ms: 228 (M^+, 98), 186 (100); ^1H-nmr (DMSO-d_6): 2.81 (3H, s, CH_3), 7.26 ~ 7.48 (3H, m, $C^{6\sim8}$-H), 8.05 (1H, d, $J_{8,9}$ = 8.3 Hz, C^9-H), 9.34 (1H, s, C^1-H).

Anal. Calcd. for $C_{12}H_8N_2O_3$: C, 63.16; H, 3.53; N, 12.28. Found: C,

63.22; H, 3.42; N, 12.17.

A similar treatment of compound **4aB** with acetic anhydride gave 79% yield of 3-acetyl-3,5-dihydro-5-methylpyrazolo[3,4-*c*]quinolin-4-one **6a**, pale yellow prisms from DMF, mp 212-214°; ir (potassium bromide): 1738 (ester CO), 1672 (lactam CO); ms: 241 (M^+, 92), 200 (100); ^{1}H-nmr (DMSO-d_6): 2.82 (3H, s, $COCH_3$), 3.64 (3H, s, N^5-CH_3), 7.24 ~ 7.53 (3H, m, $C^{6\sim8}$-H), 8.14 (1H, d, $J_{8,9}$ = 7.3 Hz, C^9-H), 9.34 (1H, s, C^1-H).

Anal. Calcd. for $C_{13}H_{11}N_3O_2$: C, 64.72; H, 4.60; N, 17.42. Found: C, 64.72; H, 4.65; N, 17.30.

2-Diazomethylchromones (**14**).

A mixture of 2-formylchromone [15] (942 mg, 5.4 mmoles) and tosylhydrazide (1.11 g, 6.0 mmoles) was stirred in ethanol (15 ml) at room temperature for 6 hours. The precipitated crude tosylhydrazone (1.54 g, 92%, 5 mmoles) was collected, suspended in dichloromethane (50 ml) and treated with 0.2 *N* sodium hydroxide (75 ml) as usual to afford 0.7 g (75% from tosylhydrazone) of **14a**, yellow needles from hexane, mp 93-94°; ir (potassium bromide): 2086 (N_2), 1663 (CO); ms: 186 (M^+, 100), 158 (M-28, 54), 102 (85); ^{1}H-nmr (deuteriochloroform): 5.12 (1H, s, CHN_2), 5.98 (1H, s, C^3-H), 7.29 ~ 7.70 (3H, m, $C^{6\sim8}$-H), 8.16 (1H, d, $J_{5,6}$ = 8.0 Hz, C^5-H).

Anal. Calcd. for $C_{10}H_6N_2O_2$: C, 64.51; H, 3.25; N, 15.05. Found: C, 64.71; H, 3.17; N, 14.83.

Treatment of **14a** with acetic acid at room temperature for 3 hours with stirring gave 2-[(acetyloxy)methyl]chromone (93%), prisms from petroleum ether, mp 68-69°; ir (potassium bromide): 1740 (ester CO), 1662 (pyron CO), 1253 (ester C-O); ms: 218 (M^+, 95), 176 (100), 147 (90); ^{1}H-nmr (deuteriochloroform): 2.20 (3H, s, CH_3), 5.02 (2H, s, CH_2), 6.38 (1H, s, C^3-H), 7.39 ~ 7.71 (3H, m, $C^{6\sim8}$-H), 8.19 (1H, d, $J_{5,6}$ = 8.0 Hz, C^5-H).

Anal. Calcd. for $C_{12}H_{10}O_4$: C, 66.05; H, 4.62. Found: C, 66.01; H, 4.47.

Similarly to 2-formylchromone, reaction of 2-formyl-5,7-dimethylchromone [15] *via* tosylhydrazone afforded **14b**, orange prisms from hexane, mp 148-150° dec; ir (potassium bromide): 2078 (N_2), 1616 (CO); ms: 214 (M^+, 100), 186 (M-28, 15); ^{1}H-nmr (deuteriochloroform): 2.38 and 2.80 (3H × 2, s × 2, CH_3 × 2), 5.01 (1H, s, CNH_2), 5.86 (1H, s, C^3-H), 6.90 (1H, s, C^6-H), 6.96 (1H, s, C^8-H).

Anal. Calcd. for $C_{12}H_{10}N_2O_2$: C, 67.28; H, 4.71; N, 13.08. Found: C, 67.33; H, 4.47; N, 12.66.

2-Diazomethyl-1-thiochromone (**15**).

Compound **15** was prepared from 2-formyl-1-thiochromone [15] by the similar procedure as described for **7aA**. Overall yield from 2-formyl-1-thiochromone, 73%, brown prisms from THF, mp 142-144° dec; ir (potassium bromide): 2060 (N_2), 1583 (CO); ms: 202 (M^+, 100), 174 (M-28, 45); ^{1}H-nmr (deuteriochloroform): 5.12 (1H, s, CNH_2), 6.55 (1H, s, C^3-H), 7.46 ~ 7.53 (3H, m, $C^{6\sim8}$-H), 8.42 ~ 8.53 (1H, m, C^5-H).

Anal. Calcd. for $C_{10}H_6N_2OS$: C, 59.39; H, 2.99; N, 13.85; S, 15.85. Found: C, 59.80; H, 2.76; N, 13.48; S, 15.66.

5-Diazomethyl-1,2-dihydro-1-methyl-2-phenyl-3*H*-pyrazol-3-one (**16**).

Compound **16** was prepared from 3-formyl-2-methyl-1-phenylpyrazol-5-one [19] by a similar procedure as described for **7aA**, total yield, 69%, yellow prisms from THF, mp 152-154° dec; ir (potassium bromide): 2082 (N_2), 1641 (CO); ms: 214 (M^+, 63), 185 (29); ^{1}H-nmr (deuteriochloroform): 2.98 (3H, s, CH_3), 4.97 (1H, s, CHN_2), 5.27 (1H, s, C^4-H), 7.39 ~ 7.43 (5H, m, C_6H_5).

Anal. Calcd. for $C_{11}H_{10}N_4O$: C, 61.67; H, 4.71; N, 26.16. Found: C, 61.71; H, 4.74; N, 26.07.

4-Diazomethyl-1-methyl-2(1*H*)-pyridinone (**17**).

4-Formyl-1-methyl-2(1*H*)-pyridinone [20] was converted as usual into its tosylhydrazone (92% yield), leaves from ethanol, mp 152-153° dec; ir (potassium bromide): 3025 (NH), 1660 (CO), 1333 and 1165 (SO_2).

Anal. Calcd. for $C_{14}H_{15}N_3O_3S$: C, 55.07; H, 4.96; N, 13.76; S, 10.50. Found: C, 55.03; H, 4.95; N, 13.75; S, 10.45.

The usual treatment of the obtained tosylhydrazone with 0.2 *N* sodium hydroxide afforded oily material from the dichloromethane extract. Compound **17** was obtained in 54% yield by extraction of the crude oil with ether followed by evaporation of the ether extract, orange prisms from petroleum ether, mp 62-63°; ir (potassium bromide): 2075 (N_2), 1650 (CO); ms: 149 (M^+, 100), 93 (87); ^{1}H-nmr (deuteriochloroform): 3.49 (3H, s, CH_3), 4.96 (1H, s, CHN_2), 5.84 (1H, dd, $J_{5,6}$ = 7.1 Hz, $J_{3,5}$ = 2.0 Hz, C^5-H), 6.06 (1H, d, $J_{3,5}$ = 2.0 Hz, C^3-H), 7.23 (1H, d, $J_{5,6}$ = 7.2 Hz, C^6-H).

Anal. Calcd. for $C_7H_7N_3O$: C, 56.37; H, 4.73; N, 28.17. Found: C, 56.22; H, 4.75; N, 28.09.

1-Methyl-2(1*H*)-pyridinone-4-carboxaldehyde Azine (**18**).

a) Compound **17** (500 mg) dissolved in toluene (3 ml) was heated on reflux with stirring for 3 hours. The white precipitate in the hot solution was collected on cooling and dried to give 254 mg (57%) of **18**, yellow prisms from DMF, mp >280°; ir (potassium bromide): 1661, 1622, 1592; ms: 270 (M^+, 100), 162 (38), 109 (18); ^{1}H-nmr (DMSO-d_6): 3.45 (6H, s, CH_3 × 2), 6.65 (2H, dd, $J_{5,6}$ = 7.1 Hz, $J_{3,5}$ = 2.0 Hz, C_5-H × 2), 6.82 (2H, d, $J_{3,5}$ = 2.0 Hz, C^3-H × 2), 7.77 (2H, d, $J_{5,6}$ = 7.2 Hz, C^6-H × 2), 8.45 (2H, s, -CH= × 2).

Anal. Calcd. for $C_{14}H_{14}N_4O_2$: C, 62.21; H, 5.22; N, 20.73. Found: C, 62.20; H, 5.27; N, 20.56.

b) A mixture of 4-formyl-1-methyl-2(1*H*)-pyridinone (1.1 g, 8 mmoles) and hydrazine (0.25 g as 80% solution, 4 mmoles) in ethanol (10 ml) was stirred at room temperature, whereby a yellow precipitate gradually appeared in the solution within 40 minutes. After 5 hours' stirring the precipitate was collected by filtration and dried to give 1.0 g (82%) of compound **18**, ir and ^{1}H-nmr spectra of which were identical with those of the sample prepared by the method a).

4-(2-Hydroxybenzoyl)-1*H*-pyrazole (**20**).

3-Formylchromone [21] was converted as usual into its tosylhydrazone **19**, leaves from DMF-ethanol (1:1), mp 215-217°; ir (potassium bromide): 3112 (NH), 1632 (CO), 1463, 1358 and 1167 (SO_2); ms: 342 (M^+, 55), 159 (100); ^{1}H-nmr (DMSO-d_6): 2.37 (3H, s, CH_3), 7.41 ~ 8.10 (10H, m), 11.55 (1H, s, NH).

Anal. Calcd. for $C_{17}H_{14}N_2O_4S$: C, 59.64; H, 4.12; N, 8.18; S, 9.36. Found: C, 59.44; H, 4.06; N, 8.20; S, 9.42.

Compound **19** (248 mg, 0.8 mmole) suspended in dichloromethane (12 ml) was added with 0.2 *N* sodium hydroxide (16 ml) on ice cooling, and the whole was vigorously stirred at room temperature. After 4 hours of stirring, the water layer was separated, acidified with acetic acid, and extracted with chloroform (5 ml × 4). From the chloroform extract 100 mg (66%) of **20** was obtained, prisms from ether, mp 123-125° (lit [17a] mp 122-125°); ir (potassium bromide): 3120 (br OH, NH), 1628 (CO); ms: 188 (M^+, 100), 120 (98); ^{1}H-nmr (DMSO-d_6): 6.87 ~ 7.93 (4H, m, benzene ring H), 8.20 (2H, s, $C^{3,5}$-H), 12.06 (2H, br s, OH, NH).

Anal. Calcd. for $C_{10}H_8N_2O_2$: C, 63.82; H, 4.29; N, 14.89. Found: C, 63.96; H, 4.26; N, 15.26.

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