# 2-Acyloxypyrazines. Convenient Acylating Agents for Amines



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2-Acyloxypyrazines were found to be useful acylating reagents for amines. The preference of the acylation was for primary amines rather than secondary ones and also for aliphatic amines rather than aromatic ones.

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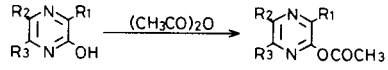
Some of heterocyclic compounds bearing acyl groups have been used for acylation of amines and alcohols (1-3). These reports prompted us to employ 2-acyloxypyrazines for acylation of amines. This paper reports that 2-acetoxy- and 2-benzoyloxy-3,6-dialkylpyrazines are applicable to our purposes.

The starting 3,6-dialkyl-2-hydroxypyrazines, such as 3,6-diethyl-2-hydroxypyrazine (**3a**) (4) and 3,6-dipropyl-2-hydroxypyrazine (**3b**), were able to be prepared in principle by an acidic hydrolysis of the corresponding 2-chloropyrazines already reported (4). However, the hydrolysis of 2-chloro-3,6-diisopropylpyrazine (**1c**) (5) and 2-chloro-3,6-

Table I

3,6-Dialkyl-2-acetoxypyrazines **5a-e**



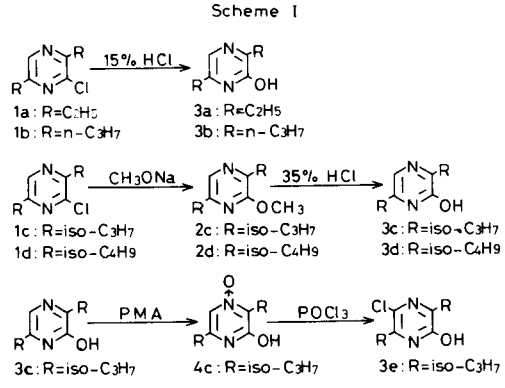

| Compounds | $R_1$ | $R_2$ | $R_3$ | Yield (%) | Bp °C/torr | Molecular Formula | Analyses (%) Calcd./Found C | H | N |
|---|---|---|---|---|---|---|---|---|---|
| **5a** | $C_2H_5$ | H | $C_2H_5$ | 80 | 108-112/2 | $C_{10}H_{14}N_2O_2$ | 61.83 | 7.26 | 14.42 |
| | | | | | | | 61.56 | 7.25 | 14.41 |
| **5b** | *n*-$C_3H_7$ | H | *n*-$C_3H_7$ | 81 | 72-75/3 | $C_{12}H_{18}N_2O_2$ | 64.84 | 8.16 | 12.60 |
| | | | | | | | 64.72 | 8.30 | 12.49 |
| **5c** | *iso*-$C_3H_7$ | H | *iso*-$C_3H_7$ | 96 | 101-102/1 | $C_{12}H_{18}N_2O_2$ | 64.84 | 8.16 | 12.60 |
| | | | | | | | 64.66 | 8.20 | 12.40 |
| **5d** | *iso*-$C_4H_9$ | H | *iso*-$C_4H_9$ | 87 | 93-98/3 | $C_{14}H_{22}N_2O_2$ | 67.17 | 8.86 | 11.19 |
| | | | | | | | 67.16 | 8.96 | 11.06 |
| **5e** | *iso*-$C_3H_7$ | Cl | *iso*-$C_3H_7$ | 98 | 85-90/5 | $C_{12}H_{17}ClN_2O_2$ | 56.14 | 6.67 | 10.91 |
| | | | | | | | 56.74 | 6.80 | 11.01 |

IR, MS and PMR Spectral Data

| Compound | IR (C=O), $cm^{-1}$ (film) | MS, m/e | PMR, $\delta$ ppm |
|---|---|---|---|
| **5a** | 1780 | 194 ($M^+$), 152 ($M^+$—$CH_2CO$) | 1.26 (3H, t, J = 8 Hz, $CH_2CH_3$), 1.30 (3H, t, J = 8 Hz, $CH_2CH_3$), 2.38 (3H, s, $CH_3CO$), 2.72 (2H, q, J = 8 Hz, $CH_2CH_3$), 2.80 (2H, q, J = 8 Hz, $CH_2CH_3$), 8.31 (1H, s, pyrazine H) |
| **5b** | 1780 | 222 ($M^+$), 180 ($M^+$—$CH_2CO$) | 0.95 (3H, t, J = 8 Hz, $CH_2CH_2CH_3$), 0.97 (3H, t, J = 8 Hz, $CH_2CH_2CH_3$), 1.68 (2H, m, $CH_2CH_2CH_3$), 1.72 (2H, m, $CH_2CH_2CH_3$), 2.37 (3H, s, $CH_3CO$), 2.70 (2H, t, J = 8 Hz, $CH_2CH_2CH_3$), 2.73 (2H, t, J = 8 Hz, $CH_2CH_2CH_3$), 8.57 (1H, s, pyrazine H) |
| **5c** | 1780 | 222 ($M^+$), 180 ($M^+$—$CH_2CO$) | 1.30 (6H, d, J = 7 Hz, $CH(CH_3)_2$), 1.35 (6H, d, J = 7 Hz, $CH(CH_3)_2$), 2.47 (3H, s, $CH_3CO$), 3.09 (1H, m, $CH(CH_3)_2$), 3.13 (1H, m, $CH(CH_3)_2$), 8.37 (1H, s, pyrazine H) |
| **5d** | 1790 | 250 ($M^+$), 208 ($M^+$—$CH_2CO$) | 0.85 (12H, d, J = 6 Hz, $CH_2CH(CH_3)_2$), 1.91 (1H, m, $CH_2CH(CH_3)_2$), 1.95 (1H, m, $CH_2CH(CH_3)_2$), 2.23 (3H, s, $CH_3CO$), 2.44 (2H, d, J = 7 Hz, $CH_2CH(CH_3)_2$), 2.48 (2H, d, J = 7 Hz, $CH_2CH(CH_3)_2$), 8.15 (1H, s, pyrazine H) |
| **5e** | 1790 | 257 ($M^+$), 215 ($M^+$—$CH_2CO$) | 1.09 (12H, d, J = 7 Hz, $CH(CH_3)_2$), 2.37 (3H, s, $CH_3CO$), 3.04 (1H, m, J = 7 Hz, $CH(CH_3)_2$), 3.44 (1H, m, J = 7 Hz, $CH(CH_3)_2$) |

diisobutylpyrazine (**1d**) (5) led to give the desired compounds only in poor yields. The preparation of 3,6-diisopropyl-2-hydroxypyrazine (**3c**) and 3,6-diisobutyl-2-hydroxypyrazine (**3d**) (6) was consequently performed *via* the methoxypyrazines (**2c** and **2d**) in satisfactory yields, as shown in Scheme I.

Scheme I




PMA = permaleic acid

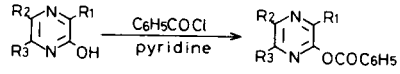
As the starting hydroxypyrazines, 5-chloro-3,6-diisopropyl-2-hydroxypyrazine (**3e**) was also adopted. Compound **3e** was obtained from **3c** *via* an *N*-oxide (**4c**), in the same way as the synthesis of 5-chloro-3,6-diisobutyl-2-hydroxypyrazine (6).

Among the acylating reagents employed in the present work, 2-acetoxypyrazines **5a-e** were prepared by heating of the corresponding 2-hydroxypyrazines **3a-e** with acetic anhydride and purified by vacuum distillation. On the other hand, the benzoylation of 2-hydroxypyrazines **3a-e** was achieved using benzoyl chloride in pyridine and the products **6a-e** were purified also by distillation *in vacuo*. The oily acyloxypyrazines thus obtained, especially the chloro derivatives **5e** and **6e**, seem to be fairly stable in a sealed vessel.

Acylation of amines took place smoothly with stirring at room temperature in benzene solutions. By extraction of the reaction mixtures with a potassium hydroxide solution, the recovery of 2-hydroxypyrazines was accomplished sa-

Table II

3,6-Dialkyl-2-benzoyloxypyrazines **6a-e**




| Compound | $R_1$ | $R_2$ | $R_3$ | Yield (%) | Bp °C/torr | Molecular Formula | Analyses (%) Calcd./Found C | H | N |
|---|---|---|---|---|---|---|---|---|---|
| **6a** | $C_2H_5$ | H | $C_2H_5$ | 61 | 124-126/1 | $C_{15}H_{16}N_2O_2$ | 70.29 | 6.29 | 10.93 |
| | | | | | | | 69.95 | 6.26 | 10.92 |
| **6b** | *n*-$C_3H_7$ | H | *n*-$C_3H_7$ | 43 | 112-117/2 | $C_{17}H_{20}N_2O_2$ | 71.80 | 7.09 | 9.85 |
| | | | | | | | 71.72 | 7.24 | 9.96 |
| **6c** | *iso*-$C_3H_7$ | H | *iso*-$C_3H_7$ | 47 | 136-139/1 | $C_{17}H_{20}N_2O_2$ | 71.80 | 7.09 | 9.85 |
| | | | | | | | 71.47 | 7.04 | 9.70 |
| **6d** | *iso*-$C_4H_9$ | H | *iso*-$C_4H_9$ | 86 | 139-143/1 | $C_{19}H_{24}N_2O_2$ | 73.05 | 7.74 | 8.97 |
| | | | | | | | 72.97 | 7.74 | 9.01 |
| **6e** | *iso*-$C_3H_7$ | Cl | *iso*-$C_3H_7$ | 80 | 117-122/1 | $C_{17}H_{19}ClN_2O_2$ | 64.05 | 6.01 | 8.79 |
| | | | | | | | 63.81 | 5.96 | 8.65 |

IR, MS and PMR Spectral Data

| Compound | IR (C=O), $cm^{-1}$ (film) | MS, m/e | PMR, δ ppm |
|---|---|---|---|
| **6a** | 1745 | 256 ($M^+$), 151 ($M^+$—$C_6H_5CO$) | 1.28 (3H, t, J = 8 Hz, $CH_2CH_3$), 1.35 (3H, t, J = 8 Hz, $CH_2CH_3$), 2.78 (2H, q, J = 8 Hz, $CH_2CH_3$), 2.83 (2H, q, J = 8 Hz, $CH_2CH_3$), 7.70 (3H, m, benzene H), 8.35 (2H, m, benzene H), 8.47 (1H, s, pyrazine H) |
| **6b** | 1750 | 284 ($M^+$), 179 ($M^+$—$C_6H_5CO$) | 0.89 (3H, t, J = 8 Hz, $CH_2CH_2CH_3$), 0.93 (3H, t, J = 8 Hz, $CH_2CH_2CH_3$), 1.65 (2H, m, $CH_2CH_2CH_3$), 1.68 (2H, m, $CH_2CH_2CH_3$), 2.72 (2H, t, J = 8 Hz, $CH_2CH_2CH_3$), 2.74 (2H, t, J = 8 Hz, $CH_2CH_2CH_3$), 7.70 (3H, m, benzene H), 8.34 (2H, m, benzene H), 8.47 (1H, s, pyrazine H) |
| **6c** | 1745 | 284 ($M^+$), 179 ($M^+$—$C_6H_5CO$) | 1.28 (6H, d, J = 7 Hz, $CH(CH_3)_2$), 1.32 (6H, d, J = 6 Hz, $CH(CH_3)_2$), 3.10 (1H, m, J = 7 Hz, $CH(CH_3)_2$), 3.20 (1H, m, J = 7 Hz, $CH(CH_3)_2$), 7.72 (3H, m, benzene H), 8.37 (2H, m, benzene H), 8.57 (1H, s, pyrazine H) |
| **6d** | 1750 | 312 ($M^+$), 207 ($M^+$—$C_6H_5CO$) | 0.83 (12H, d, J = 7 Hz, $CH_2CH(CH_3)_2$), 2.05 (1H, m, J = 6 Hz, $CH_2CH(CH_3)_2$), 2.10 (1H, m, J = 7 Hz, $CH_2CH(CH_3)_2$), 2.54 (4H, d, J = 6 Hz, $CH_2CH(CH_3)_2$), 7.59 (3H, m, benzene H), 8.20 (2H, m, benzene H), 8.35 (1H, s, pyrazine H) |
| **6e** | 1750 | 318 ($M^+$), 213 ($M^+$—$C_6H_5CO$) | 1.29 (12H, d, J = 7 Hz, $CH(CH_3)_2$), 3.27 (1H, m, J = 7 Hz, $CH(CH_3)_2$), 3.50 (1H, m, J = 7 Hz, $CH(CH_3)_2$), 7.75 (3H, m, benzene H), 8.40 (2H, m, benzene H) |

tisfactorily. The amides formed were confirmed by the comparison of the ir spectra with the ones of the authentic samples.

The concurrent reactions suggested that the preference of the acylation is for primary amines rather than secondary amines and also for aliphatic amines rather than aromatic amines. Although the reagents were applied to the acylation of alcohols, the attempts met with failure.

## EXPERIMENTAL

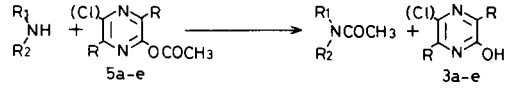
Melting points were recorded on a Yanagimoto micro-melting point apparatus and are uncorrected. Boiling points are also uncorrected. All uv spectra were taken in 95% ethanol using a Hitachi Model 557 spectrophotometer, ir spectra on a Shimadzu IR-400 spectrometer and pmr spectra in deuteriochloroform using Varian EM-360 and EM-390 instruments with tetramethylsilane as an internal standard. Mass spectra were obtained with Hitachi RMU-7L and M-80 spectrometers.

1) 3,6-Dipropyl-2-hydroxypyrazine (**3b**).

A mixture of **1b** (1.98 g, 10 ml) and 15% hydrochloric acid (20 ml) was refluxed for 1.5 hours and then made alkaline with solid potassium carbonate. The precipitates (1.70 g, 94%) were collected by suction and recrystallized from hexane to give **3b** as colorless needles, mp 140-142°; uv: λ max 227 (log ε = 3.67), 323 (3.68) nm; ir (potassium bromide): 1650 $cm^{-1}$ (C=O); pmr: δ 1.04 (6H, t, J = 7 Hz, $CH_2CH_2CH_3$), 1.70 (4H, m, J = 7 Hz, $CH_2CH_2CH_3$), 2.57 (2H, t, J = 7 Hz, $CH_2CH_2CH_3$), 2.80 (2H, t, J = 7 Hz, $CH_2CH_2CH_3$), 7.27 (1H, s, pyrazine H), 13.88 (1H, s, OH); ms: m/e 180 ($M^+$).

Table III

Acetylation of Amines Using 2-Acetoxypyrazines **5a-e**

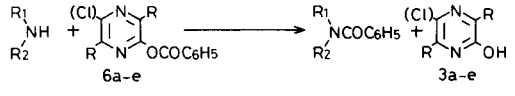



| Entry | Amines | Reagents | Yields of Acetates (%) | Mp (°C) or Bp (°C/torr) | Mp (°C) or Bp (°C/torr) (lit) |
|---|---|---|---|---|---|
| 1 | aniline $R_1 = C_6H_5$, $R_2 = H$ | **5a** | 96 | 114-115 | 114 (7) |
| 2 | aniline $R_1 = C_6H_5$, $R_2 = H$ | **5b** | 87 | | |
| 3 | aniline $R_1 = C_6H_5$, $R_2 = H$ | **5c** | 81 | | |
| 4 | aniline $R_1 = C_6H_5$, $R_2 = H$ | **5d** | 99 | | |
| 5 | aniline $R_1 = C_6H_5$, $R_2 = H$ | **5e** | 98 | | |
| 6 | benzylamine $R_1 = C_6H_5CH_2$, $R_2 = H$ | **5a** | 91 | 66-68 | 65 (7) |
| 7 | benzylamine $R_1 = C_6H_5CH_2$, $R_2 = H$ | **5c** | 98 | | |
| 8 | benzylamine $R_1 = C_6H_5CH_2$, $R_2 = H$ | **5e** | 88 | | |
| 9 | pyrrolidine $R_1—R_2 = —(CH_2)_4—$ | **5a** | 68 | 60-65/3 (a) | 108/15 (8) |
| 10 | pyrrolidine $R_1—R_2 = —(CH_2)_4—$ | **5c** | 69 | | |
| 11 | pyrrolidine $R_1—R_2 = —(CH_2)_4—$ | **5e** | 74 | | |

(a) Oil bath temperature.

Table IV

Benzoylation of Amines Using 2-Benzoyloxypyrazines **6a-e**




| Entry | Amines | Reagents | Yields of Benzoates (%) | Mp (°C) or Bp (°C/torr) | Mp (°C) or Bp (°C/torr) (lit) |
|---|---|---|---|---|---|
| 1 | aniline $R_1 = C_6H_5$, $R_2 = H$ | **6a** | 98 | 160-161 | 160 (7) |
| 2 | aniline $R_1 = C_6H_5$, $R_2 = H$ | **6b** | 89 | | |
| 3 | aniline $R_1 = C_6H_5$, $R_2 = H$ | **6c** | 93 | | |
| 4 | aniline $R_1 = C_6H_5$, $R_2 = H$ | **6d** | 97 | | |
| 5 | aniline $R_1 = C_6H_5$, $R_2 = H$ | **6e** | 96 | | |
| 6 | benzylamine $R_1 = C_6H_5CH_2$, $R_2 = H$ | **6a** | 96 | 108-110 | 105 (7) |
| 7 | benzylamine $R_1 = C_6H_5CH_2$, $R_2 = H$ | **6c** | 95 | | |
| 8 | benzylamine $R_1 = C_6H_5CH_2$, $R_2 = H$ | **6e** | 89 | | |
| 9 | pyrrolidine $R_1—R_2 = —(CH_2)_4—$ | **6a** | 75 | 102-107/1 (a) | 132/2 (9) |
| 10 | pyrrolidine $R_1—R_2 = —(CH_2)_4—$ | **6c** | 73 | | |
| 11 | pyrrolidine $R_1—R_2 = —(CH_2)_4—$ | **6e** | 83 | | |

(a) Oil bath temperature.

Table V

Concurrent Acylation of Amine Mixtures

| Entry | Amine Mixtures: Amine (I) | Amine (II) | Reagents | Products | Yields (%) |
|---|---|---|---|---|---|
| 1 | aniline | *N*-methylaniline | **5a** | acetanilide | 94 |
| 2 | aniline | *N*-methylaniline | **5e** | acetanilide | 96 |
| 3 | aniline | *N*-methylaniline | **6a** | benzanilide | 95 |
| 4 | aniline | *N*-methylaniline | **6e** | benzanilide | 96 |
| 5 | aniline | benzylamine | **5a** | *N*-acetylbenzylamine | 88 |
| 6 | aniline | benzylamine | **5e** | *N*-acetylbenzylamine | 90 |
| 7 | aniline | benzylamine | **6a** | *N*-benzoylbenzylamine | 97 |
| 8 | aniline | benzylamine | **6e** | *N*-benzoylbenzylamine | 91 |

*Anal.* Calcd. for $C_{10}H_{16}N_2O$: C, 66.63; H, 8.95; N, 15.54. Found: C, 66.72; H, 8.98; N, 15.56.

2) 3,6-Diisopropyl-2-methoxypyrazine (**2c**).

A mixture of **1c** (5.00 g, 25 mmoles) and sodium methoxide, prepared from sodium (3.00 g, 130 mg-atoms) and absolute methanol (50 ml), was heated at 120° for 3 hours in a sealed tube and then methanol was evaporated off *in vacuo*. The residue was triturated with water and extracted with ether. The ether layer was washed with water, dried over sodium sulfate and concentrated. The crude product was purified by distillation to give **2c** as a colorless oil (4.80 g, 99%), bp 91-93°/8 torr; uv: λ max 216 (log ε = 3.93), 281 (3.79), 294 (3.85) nm; pmr: δ 1.29 (6H, d, J = 6 Hz, $CH(CH_3)_2$), 1.31 (6H, d, J = 6 Hz, $CH(CH_3)_2$), 3.13 (1H, m, J = 6 Hz, $CH(CH_3)_2$), 3.17 (1H, m, J = 6 Hz, $CH(CH_3)_2$), 4.03 (3H, s, $OCH_3$), 8.07 (1H, s, pyrazine H) ppm; ms: m/e 194 ($M^+$).

*Anal.* Calcd. for $C_{11}H_{18}N_2O$: C, 68.00; H, 9.34; N, 14.42. Found: C, 68.17; H, 9.47; N, 14.39.

3) 3,6-Diisobutyl-2-methoxypyrazine (**2d**).

A mixture of **1d** (4.98 g, 22 mmoles) and sodium methoxide, prepared from sodium (3.00 g, 130 mg-atoms) and absolute methanol (50 ml), was worked up as before to give **2d** as a colorless oil (4.75 g, 97%) bp 113-114°/7 torr; uv: λ max 222 (log ε = 3.74), 283 (3.74), 298 (3.77) nm; pmr: δ 0.82 (12H, d, J = 7 Hz, $CH_2CH(CH_3)_2$), 2.15 (1H, m, J = 7 Hz, $CH_2CH(CH_3)_2$), 2.20 (1H, m, J = 7 Hz, $CH_2CH(CH_3)_2$) 2.45 (2H, d, J = 7 Hz, $CH_2CH(CH_3)_2$), 2.58 (2H, d, J = 7 Hz, $CH_2CH(CH_3)_2$), 3.88 (3H, s, $OCH_3$), 7.93 (1H, s, pyrazine H) ppm; ms: m/e 222 ($M^+$).

*Anal.* Calcd. for $C_{13}H_{22}N_2O$: C, 70.23; H, 9.97; N, 12.60. Found: C, 70.27; H, 10.03; N, 12.52.

4) 3,6-Diisopropyl-2-hydroxypyrazine (**3c**).

A mixture of **2c** (1.94 g, 10 mmoles) and concentrated hydrochloric acid (50 ml) was refluxed for 1.5 hours and neutralized with solid potassium carbonate. The precipitates (1.75 g, 97%) were collected by suction and recrystallized from methanol to furnish colorless needles, mp 141-142°; λ max 225 (log ε = 2.91), 320 (2.87) nm; ir (potassium bromide): 1645 $cm^{-1}$ (C=O); pmr: δ 1.25 (6H, d, J = 7 Hz, $CH(CH_3)_2$), 1.35 (6H, d, J = 7 Hz, $CH(CH_3)_2$), 2.88 (1H, m, J = 7 Hz, $CH(CH_3)_2$), 3.45 (1H, m, J = 7 Hz, $CH(CH_3)_2$), 7.37 (1H, s, pyrazine H), 13.70 (1H, s, OH) ppm; ms: m/e 180 ($M^+$).

*Anal.* Calcd. for $C_{10}H_{16}N_2O$: C, 66.63; H, 8.95; N, 15.54. Found: C, 66.83; H, 8.93; N, 15.62.

5) 3,6-Diisobutyl-2-hydroxypyrazine (**3d**).

A solution of **2d** (2.08 g, 9.37 mmoles) in concentrated hydrochloric acid (50 ml) was heated under reflux for 1.5 hours and worked up the same as described in the case of the synthesis of **3c**, to give **3d** as a colorless solid (1.89 g, 97%), which was recrystallized from acetone to furnish colorless prisms, mp 152-153° [lit (6) mp 149-150°].

6) 3,6-Diisopropyl-2-hydroxypyrazine 4-Oxide (**4c**).

A solution of **3c** (1.80 g, 10 mmoles), 90% hydrogen peroxide (0.57 g, 15 mmoles) and maleic anhydride (1.70 g, 17.5 mmoles) in chloroform (100 ml) was allowed to stand for 15 hours, and then refluxed for 2 hours. The reaction mixture was washed with water and 5% potassium bicarbonate, succesively. The organic layer was dried over sodium sulfate and concentrated *in vacuo*. The resulting solid was chromatographed on silica gel (Wakogel C-200, 50 g) using benzene and chloroform as developer. From the fractions eluted with the 1:1 mixture, the starting material (0.19 g, 11%) was recovered. Chloroform eluted **4c** as a colorelss solid (1.47 g, 75%), which was recrystallized from methanol to furnish colorless needles, mp 260-262° dec; uv: λ max 225 (log ε = 4.27), 230 (4.26), 276 (3.91), 330 (3.90) nm; ir (potassium bromide): 1640 $cm^{-1}$ (C=O); pmr: δ 1.21 (12H, d, J = 6 Hz, $CH(CH_3)_2$), 2.66 (1H, m, J = 6 Hz, $CH(CH_3)_2$), 3.78 (1H, m, J = 6 Hz, $CH(CH_3)_2$), 6.97 (1H, s, pyrazine H), 12.80 (1H, s, OH) ppm; ms: m/e 196 ($M^+$).

*Anal.* Calcd. for $C_{10}H_{16}N_2O_2$: C, 61.20; H, 8.22; N, 14.28. Found: C, 61.14; H, 8.13; N, 14.32.

7) 5-Chloro-3,6-diisopropyl-2-hydroxypyrazine (**3e**).

A mixture of **4c** (3.92 g, 10 mmoles) and phosphoryl chloride (30 ml) was refluxed for 1 hour and poured into ice water. The solution was made alkaline with solid potassium bicarbonate and extracted with chloroform. The extract was dried over sodium sulfate and concentrated to give **3e** as a colorless solid (4.12 g, 99%), which was recrystallized from methanol to furnish colorless needles, mp 174-176°; uv: λ max 225 (log ε = 3.91), 307 (3.82) nm; ir (potassium bromide): 1640 $cm^{-1}$ (C=O); pmr: δ 1.20 (6H, d, J = 7 Hz, $CH(CH_3)_2$), 1.31 (6H, d, J = 7 Hz, $CH(CH_3)_2$), 3.29 (1H, m, J = 7 Hz, $CH(CH_3)_2$), 3.33 (1H, m, J = 7 Hz, $CH(CH_3)_2$), 11.87 (1H, s, OH) ppm; ms: m/e 214 ($M^+$).

*Anal.* Calcd. for $C_{10}H_{15}ClN_2O$: C, 55.94; H, 7.04; N, 13.05. Found: C, 56.12; H, 7.01; N, 13.09.

8) General Procedure for Preparation of 2-Acyloxypyrazines.

A) 2-Acetoxypyrazines (**5a-e**).

A 2-hydroxypyrazine (**3a-e**: 10 mmoles) was heated under reflux in acetic anhydride (40 ml) for 1.5 hours. After the reaction mixture was concentrated to dryness *in vacuo*, the residue was triturated with water, neutralized with potassium carbonate and extracted with ether. The organic layer was dried over sodium sulfate and concentrated to give the corresponding 2-acetoxypyrazine (**5a-e**), which was subjected to a vacuum distillation.

B) 2-Benzoyloxypyrazines (**6a-e**).

To an ice-cooled mixture of a 2-hydroxypyrazine (**3a-e**: 10 mmoles) and pyridine (20 ml), benzoyl chloride (15 mmoles) was added dropwise under stirring in 10 minutes. After being allowed to stand further for 3 hours under ice-cooling, the reaction mixture was poured into ice-water and extracted with ether. The ether layer was washed with 2*N* hydrochloric acid, 1*N* sodium hydroxide and water, successively, dried over sodium sulfate and concentrated to give a pale yellow oil, which was purified by

distillation *in vacuo*.

9) General Procedure for Acylation of Amines.

A mixture of an amine (12 mmoles) and the reagent (12 mmoles) was stirred in benzene (50 ml) for 15 hours at room temperature. The reaction mixture was washed with 2*N* potassium hydroxide and 2*N* hydrochloric acid, successively, and then dried over sodium sulfate. The solvent was removed to leave an amide, which was purified by recrystallization or distillation.

10) General Procedure for the Concurrent Acylation.

A mixture of two amines (10 mmoles:10 mmoles) and the reagent (10 mmoles) was stirred in benzene (50 ml) for 15 hours at room temperature. The reaction mixture was worked up as described in the above mentioned experiments. The purity of the products was estimated by glc (1.5% SE-30 on Chromosorb W, 3 mm × 1.5 m column, Shimadzu GC-4B instrument).

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