$NCH_2CH_2CH_3$), 2.55 (s, 3, NCH_3), 2.82 (s, 3, NCH_3), 2.42 (t, 2, $NCH_2CH_2CH_3$), and 2.58 ppm (q, 2, $CH_3CH_2C{=}O$).

Anal. Calcd for $C_8H_{18}N_2O$: C, 60.72; H, 11.47; N, 17.70. Found: C, 60.86; H, 11.50; N, 17.90.

1,2-Dipropyl-1,2-diethylhydrazine.—By following the usual procedure, there was obtained **1,2-dipropyl-1,2-diethylhydrazine** (82%): bp 74–76° (10 mm); $n^{20}D$ 1.4322; nmr (CCl_4) 0.88 [t, 6, $N(CH_2)_2CH_3$], 1.0 (t, 6, NCH_2CH_3), 1.38 (m, 4, $NCH_2CH_2CH_3$), 2.43 (t, 4, $NCH_2CH_2CH_3$), and 2.40 ppm (q, 4, NCH_2CH_3).

Anal. Calcd for $C_{10}H_{24}N_2$: C, 69.70; H, 14.04; N, 16.26. Found: C, 69.81; H, 14.26; N, 16.30.

When the reaction mixture was refluxed during the reduction only for 2 hr instead of 24 hr, there was also obtained **1-propionyl-2-propyl-1,2-diethylhydrazine** (10%): bp 58° (0.31 mm); $n^{20}D$ 1.4533; ir (neat) 2990 (CH) and 1653 cm^{-1} (C=O); nmr (CCl_4) 0.90 [t, 3, $N(CH_2)_2CH_3$], 1.0 (t, 3, $O{=}CNCH_2CH_3$), 1.05 (t, 3, $O{=}CCH_2CH_3$), 1.38 (m, 2, $NCH_2CH_2CH_3$), 2.40 (q, 2, NCH_2CH_3), 2.50 (t, 2, $NCH_2CH_2CH_3$), 2.70 (q, 2, $OCCH_2CH_3$), and 3.23 ppm (q, 2, $OCNCH_2CH_3$).

Anal. Calcd for $C_{10}H_{22}N_2O$: C, 64.47; H, 11.90; N, 15.04. Found: C, 64.45; H, 12.12; N, 15.07.

1,2-Diethyl-1,2-dimethylhydrazine.—By following the typical procedure, there was obtained from 4.32 g (30 mmol) of 1,2-diacetyl-1,2-dimethylhydrazine 2.61 g (75%) of 1,2-diethyl-1,2-dimethylhydrazine: bp 92–94°; $n^{20}D$ 1.4091 [lit.[4] bp 93–94° (752 mm); $n^{27}D$ 1.4121]; ir (neat) 2950 and 2800 cm^{-1} (CH); nmr (CCl_4) 1.02 (t, 6, CH_2CH_3), 2.22 (s, 6, NCH_3), and 2.48 ppm (q, 4, CH_2CH_3).

When the reduction mixture was refluxed for only 2 hr instead of 24 hr, the major product was identified by glpc analysis as the half-reduced 1-acetyl-2-ethyl-1,2-dimethylhydrazine (46% yield): $n^{20}D$ 1.4423; ir (neat) 2960, 2850 (CH), and 1665 cm^{-1} (CO); nmr (CCl_4) 1.01 (t, 3, CH_3CH_2), 2.03 (s, 3, CH_3CO), 2.55 (s, 3, NCH_3), 2.7 (q, 2, CH_2CH_3), and 2.78 ppm (s, 3, H_3CNCO).

Anal. Calcd for $C_6H_{14}N_2O$: C, 55.35; H, 10.84; N, 21.52. Found: C, 55.27; H, 10.91; N, 21.26.

Tetraethylhydrazine and 1-Acetyl-1,2,2-triethylhydrazine.—From 1,2-diacetyl-1,2-diethylhydrazine, there were obtained **tetraethylhydrazine** (70%), bp 56–58° (46 mm) [lit.[17] bp 52–53° (42 mm)], $n^{20}D$ 1.4215, and **1-acetyl-1,2,2-triethylhydrazine** (8%): bp 34–36° (0.33 mm); $n^{20}D$ 1.4498; ir (neat) 2950 (CH) and 1653 cm^{-1} (CO); nmr (CCl_4) 1.02 [t, 6, $N(CH_2CH_3)_2$], 1.17 (t, 3, $O{=}CNCH_2CH_3$), 2.0 (s, 3, $CH_3C{=}O$), 2.72 [q, 4, $N(CH_2CH_3)_2$], and 3.20 ppm (q, 2, $O{=}CNCH_2CH_3$).

Anal. Calcd for $C_8H_{18}N_2O$: C, 60.72; H, 11.47; N, 17.70. Found: C, 60.48; H, 11.61; N, 17.86.

1,2-Dibenzyl-1,2-dimethylhydrazine (**13**).—From 1,2-dibenzoyl-1,2-dimethylhydrazine was obtained **13** (60%): bp 110–112° (0.1 mm); $n^{20}D$ 1.5566 [lit.[4] bp 118–120° (0.15 mm), $n^{20}D$ 1.5538]; nmr (CCl_4) 2.3 [s, 6, $N(CH_3)_2$], 3.7 [s, 4, $N(CH_2)_2$], and 7.3 ppm (s, 10, aromatic H). **N-Methylbenzylamine** (28%) was also obtained: bp 50–52° (3 mm); $n^{20}D$ 1.5242; ir (neat) 3350 cm^{-1} (NH); nmr (CCl_4) 1.9 (s, 1, NH), 2.3 (s, 3, NCH_3), 3.7 (s, 2, NCH_2), and 7.3 ppm (s, 5, aromatic H).

Registry No.—Diborane, 19287-45-7; **2a**, 23359-97-9; **2b**, 23346-48-7; **2c**, 23346-49-8; **2d**, 23346-50-1; **2f**, 23346-51-2; **2g**, 505-19-1; **3a**, 23346-53-4; **3b**, 23346-54-5; **3c**, 23346-55-6; **3d**, 23346-56-7; **4a**, 23346-57-8; **4a** dipicrate, 23346-58-9; **4c**, 23346-59-0; **4c** dipicrate, 23359-98-0; **4d**, 19435-69-9; **4d** dipicrate, 23346-61-4; **4f**, 23346-62-5; **4f** dihydrochloride, 23346-63-6; **7**, 1215-52-7; **8**, 23337-87-3; **10**, 23337-88-4; **11**, 23337-89-5; 1-(*p*-methoxybenzoyl)-2-(*p*-methoxybenzyl)hydrazine, 23359-99-1; 1-(*p*-chlorobenzoyl)-2-(*p*-chlorobenzyl)hydrazine, 23337-90-8; 1,2-dipropyl-1,2-diethylhydrazine, 23337-91-9; 1-propionyl-2-propyl-1,2-diethylhydrazine, 23337-92-0; 1,2-diethyl-1,2-dimethylhydrazine, 23337-93-1; 1-acetyl-1,2,2-triethylhydrazine, 23389-69-7.

Acknowledgment.—We thank the Purdue Research Foundation for financial support of part of this work.

(17) O. Westphal and M. Eucken, *Chem. Ber.*, **76B**, 1137 (1943).

Hydroxamic Acids and N-Hydroxyimides Related to Pyridine, Pyrazine, and Quinoxaline

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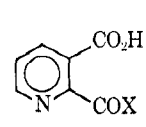
Received January 28, 1969

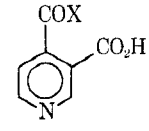
The *o*-carboxyhydroxamic acids **1b**, **2b**, **8a**, and **9a** were prepared and subjected to Lossen rearrangement. In an inert medium, the isocyanate intermediate from **1b** gives the cyclic anhydride **3**, which reacts readily with water or methanol. In the presence of methanol, *o*-amino esters were obtained in all cases, indicating that cyclization of the isocyanate is more rapid than its reaction with methanol. Rearrangement of N-(benzoyloxy)-quinolinimide **12b** and N-(benzoyloxy)cinchomeronimide **14b** gave amino acids **4a** and **15**, respectively.

In this study we have extended our earlier findings[2] on the Lossen rearrangement of *o*-carboxyhydroxamic salts. The 3-carboxyhydroxamic acids **1b** and **2b** were obtained from the corresponding methyl esters **1a** and **2a** by reaction with hydroxylamine. The esters were obtained by treatment of quinolinic and cinchomeronic anhydrides, respectively, with methanol. We were unable to isolate the isomeric methyl 2-carboxynicotinate from brief heating of quinolinic anhydride in methanol,[3] but both isomeric benzyl esters were obtained with benzyl alcohol.

The benzoyl hydroxamates **1c** and **2c** were prepared from the acids with benzoyl chloride, and were converted into the monosodium salts for rearrangement. On heating in toluene the salts gave mixtures of the cyclic anhydrides **3**[4] and **6** and the amino acids **4a** and **7a**. The aminonicotinic acid presumably arose from traces of water; a sample of the salt of **1c** that had been stored for a week gave only **4a** (76%). The rearrange-



1a, X = OCH_3
b, X = NHOH
c, X = $NHOCOC_6H_5$



2a, X = OCH_3
b, X = NHOH
c, X = $NHOCOC_6H_5$

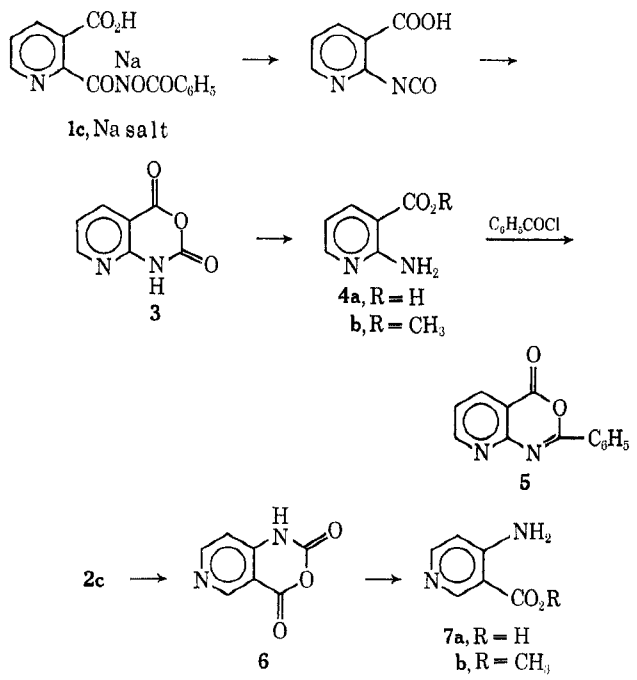
(1) Abbott Fellow, 1962–1963; Lubrizol Fellow, 1963–1965.

(2) C. D. Hurd, C. M. Buess, and L. Bauer, *J. Org. Chem.*, **17**, 865 (1952); **19**, 1140 (1954).

(3) J. Kenyon and K. Thaker, *J. Chem. Soc.*, 2531 (1957).

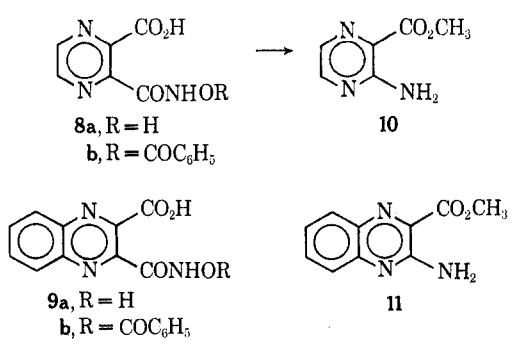
(4) An alternative preparation of **3** by $Pb(OAc)_4$ oxidation of 2-carbamylnicotinic acid has recently been described by A. L. J. Beckwith and R. J. Hickman, *ibid.*, *C*, 2756 (1969).

ment of **1b**, as the disodium salt, was also carried out in cold aqueous solution with benzenesulfonyl chloride[5] to give **4a**. The azlactone **5** was obtained from **4a** with excess benzoyl chloride.



The anhydrides **3** and **6** undergo hydrolysis or alcoholysis much more rapidly than isatoic anhydride, which can be recrystallized from alcohol. Treatment of **3** or **6** with warm methanol gives **4b** and **7b**. These esters are also obtained by heating the benzoylhydroxamic salts in toluene–methanol (8:1). The formation of **4b** and **7b**, rather than the methyl carbamates, $HOOC(NC_5H_3)NHCOOCH_3$, when methanol is present during the rearrangement, demonstrates that cyclization of the intermediate isocyanates to **3** and **6** is much more rapid than reaction of the isocyanate with methanol.

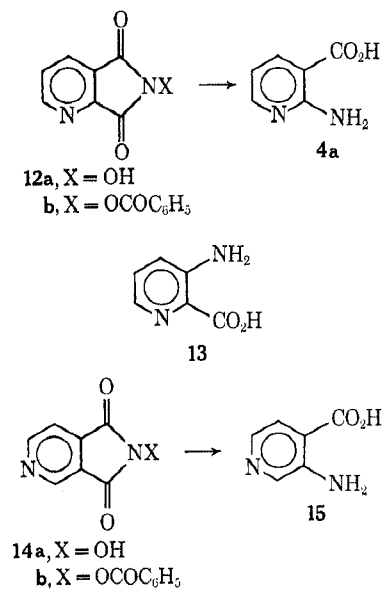
o-Carboxyhydroxamic acids **8a** and **9a** were obtained from pyrazine- and quinoxaline-2,3-dicarboxylic anhydrides by treatment with hydroxylamine in methanolic sodium methoxide. The benzoyl derivatives of **8** and **9** and the sodium salts contained water or methanol of crystallization. Heating the methanolates in toluene gave the amino esters **10** and **11**, presumably again by attack of methanol on the cyclic anhydride.



For comparison with the *o*-carboxyhydroxamic esters, the N-hydroxyimides **12a** and **14a** were prepared from **1b** and **2b**, respectively, in refluxing thionyl chloride. Only a low yield of **12** was obtained from the reaction of quinolinic anhydride and hydroxylamine. The hydroxyimide structures were confirmed by ir bands at 5.6 and 5.7–5.8 μ, and formation of a bright red color in base, paralleling the properties of N-hydroxyphthalimide.[6] The benzoates **12b** and **14b** were prepared by direct benzoylation or by cyclization of **1c** and **2c** with thionyl chloride.

Rearrangement of **14b** led to 3-aminoisonicotinic acid (**15**) in 54% yield, attack of base evidently occurring predominately at the C-4 carbonyl. This result parallels the course of the Hofmann rearrangement of **14** (X = H) to **15** with NaOBr or NaOCl.[7]

With **12b**, the Lossen rearrangement product isolated in 43% yield was 2-aminonicotinic acid (**4a**). The related Hofmann rearrangement has been reported[8] to give 3-aminopicolinic acid (**13**) with NaOCl, but, with excess NaOBr, both **4a** and **13** have been isolated.[9]



The reactivity of the C-4 carbonyl in **14b** and the C-2 carbonyl in **12b** should be comparable, and little difference was observed in the time required for the two rearrangements. It is surprising, therefore, that **4a**, arising from C-3 attack, rather than **13**, appears to be the major product from **12b**.

Experimental Section

Microanalyses for C, H, and N were done by Micro-Tech Laboratories, Skokie, Ill. Quinolinic anhydride, mp 136–136.5°, cinchomeronic anhydride, mp 75–77°, 2,3-pyrazinedicarboxylic anhydride, mp 224–225° dec with darkening at 170°, 2,3-quinoxalinedicarboxylic anhydride, mp 253° dec, and methyl 3-carboxypicolinate (**1a**), mp 122–123°,[3] were synthesized by known methods.

Sodium 2-(Methoxycarbonyl)nicotinate.—Equimolar (0.03) parts of methanol solutions of **1a** and CH_3ONa were mixed. When the salt started to separate from the 30 ml of solution, 130 ml of absolute ether–hexane (4:9)w as added: yield of rinsed and dried salt, 5.8 g (94%).

Anal. Calcd for $C_8H_6NO_4Na$: Na, 11.21. Found: Na, 11.14.

(5) C. D. Hurd and L. Bauer, *J. Amer. Chem. Soc.*, **76**, 2791 (1954); L. Bauer, *J. Org. Chem.*, **21**, 1182 (1956).

(6) L. Bauer and S. V. Miarka, *J. Amer. Chem. Soc.*, **79**, 1983 (1957); *J. Org. Chem.*, **24**, 1293 (1959).

(7) S. Blumenfeld, *Monatsh. Chem.*, **16**, 703 (1895). S. Gabriel and J. Colman, *Ber.*, **35**, 2831 (1902). K. Blanchard, *et al.*, *Bull. Johns Hopkins Hosp.*, **91**, 339 (1952); *Chem. Abstr.*, **47**, 10536 (1953).

(8) E. Sucharda, *Ber.*, **58**, 1727 (1925); E. Ochiai and I. Arai, *J. Pharm. Soc. Jap.*, **59**, 458 (1939).

(9) L. Fibel and P. Spoerri, *J. Amer. Chem. Soc.*, **70**, 3908 (1948).

Quinolinic Anhydride and Benzyl Alcohol.—A mixture of the anhydride (14.9 g), the alcohol (13.0 g), and benzene (100 ml) was heated at reflux for 2 hr, whereby some of the ester precipitated. On cooling, 15 g (58%) of ester, mp 151–152°, was obtained. Recrystallization from ethanol–water gave long needles, mp 152–153°. The substance is believed to be benzyl 3-carboxypicolinate by analogy to similar reactions[8,10] of quinolinic and 3-nitrophthalic anhydrides with alcohols.

Anal. Calcd for $C_{14}H_{11}NO_4$: N, 5.45; neut equiv, 257.2. Found: N, 5.28; neut equiv, 255.2.

The benzene filtrate was concentrated and the residue was dissolved in ethyl acetate. Hexane, added to incipient cloudiness, promoted formation of small, colorless cubic crystals after several days at 0°; yield 5 g (19%), mp 89–90°. After recrystallization from ethyl acetate–hexane, mp 90–91°. This was considered to be benzyl 2-carboxynicotinate. Mixture melting point of the 2- and 3-benzyl esters was 75–125°.

Anal. Calcd for $C_{14}H_{11}NO_4$: N, 5.45; neut equiv, 257.2. Found: N, 5.18; neut equiv, 256.

Disodium 3-Carboxypicolinohydroxamate.—A cool solution of **1a** (0.065 mol in 50 ml of CH_3OH) was added to 0.078 mol of hydroxylamine and 0.13 mol of CH_3ONa in 110 ml of methanol. [Alternatively, sodium 2-(methoxycarbonyl)nicotinate may be used with no added CH_3ONa.] The desired disodium salt precipitated during 6 hr, when 75 ml of dry ether–hexane (1:2) was added to complete the precipitation: yield, 12.7–13 g (86–88%) after drying *in vacuo* over P_2O_5.

Anal. Calcd for $C_7H_4N_2O_4Na_2$: Na, 20.34. Found: Na, 20.48, 20.22.

Disodium 3-Carboxyisonicotinohydroxamate.—This was made in the same way from **2a**; yield 92%. Ester **2a** was prepared from cinchomeronic anhydride and methanol following directions of Kaas.[11]

Anal. Calcd for $C_7H_4N_2O_4Na_2$: Na, 20.34. Found: Na, 21.01.

Disodium 3-Carboxy-2-pyrazinecarbohydroxamate.—A solution of hydroxylamine (0.24 mol) in 225 ml of methanol was added to a solution of 2,3-pyrazinedicarboxylic anhydride in 350 ml of methanol. Then 200 ml of methanol containing 0.24 mol CH_3ONa was slowly added. A bright yellow, gelatinous mass soon separated. After 30 min, ether and pentane were added and the salt was collected, rinsed (ether), and dried; yield, 95%.

Anal. Calcd for $C_6H_3N_3O_4Na_2$: Na, 20.25. Found: Na, 20.15.

Disodium 3-Carboxy-2-quinoxalinecarbohydroxamate.—The same plan was followed; yield 96%. It was also an orange, gelatinous mass.

Anal. Calcd for $C_{10}H_5N_3O_4Na_2$: Na, 16.54. Found: Na, 16.82.

The free hydroxamic acids gave intense violet red colors with $FeCl_3$ solution.

3-Carboxypicolinohydroxamic Acid, 1b.—This acid was made by suspending 1 g of its disodium salt in 50 ml of ethyl acetate, adding 2 ml of cold 5 *N* HCl, and shaking the mixture. The solid that separated was crystallized from water; yield 0.4 g, mp 164° dec. It was insoluble in ethyl acetate and chloroform. Infrared (KBr), with strong peaks noted unless designated otherwise as m (medium), w (weak), or b (broad): 3.10–3.90 (b), 5.90 (b), 6.30, 6.65, 6.85, 7.05, 7.50, 7.60, 8.40 (m), 8.60 (m), 9.10, 9.35 (m), 9.60, 9.90 (w), 10.90, 11.85 (w), 12.15, 12.50, 14.12, 14.50 (m), 15.27 (m) μ.

Anal. Calcd for $C_7H_6N_2O_4$: N, 15.38. Found: N, 15.22.

3-Carboxyisonicotinohydroxamic Acid, 2b.—To a solution of the disodium salt (2 g) in 12 ml of cold water was added 3.5 ml of 5 *N* HCl. After cooling and scratching the walls of the container the acid separated: yield, air dried, 1.6 g; mp 178–179° dec; after vacuum drying for 24 hr at 77°, mp 179–180° dec. Attempts to purify **2b** by recrystallization were fruitless. The original crude product, mp 179–180°, analyzed acceptably for H (only 0.04% low) but was 1.3% low for carbon. This uncrystallized material was taken directly to the benzoylation step.

3-Carboxy-2-pyrazinecarbohydroxamic Acid, 8a.—The method given for **2b** worked well for **8a**; yield 0.82 g of colorless cubes from 1 g of the disodium salt. After recrystallization from ethanol–water, the melting point was 151–152° dec. It was soluble in alcohol and hot water but dissolved with difficulty in ethyl acetate. Analysis showed that **8a** is a monohydrate, stable for 17 hr under diminished pressure at 80°: ir 3.12, 3.30, 3.55, 5.82, 6.01, 6.15 μ, and 12 other bands.

Anal. Calcd for $C_6H_5N_3O_4 \cdot H_2O$: N, 20.89. Found: N, 20.68.

3-Carboxy-2-quinoxalinecarbohydroxamic Acid, 9a.—Addition of dilute HCl to a solution of 3 g of the disodium salt in 25 ml of water to a pH of about 1 caused separation of 2 g of the monohydrate of **9a**. Its melting point was 213–216° dec when heated slowly in a capillary tube, or at 206–208° dec if placed in a bath preheated to 200°. Attempted recrystallization lowered the melting point. Ir showed 3.40 (b), 5.90, 6.00, 6.70 (w), 7.21 (w), 9.50 (m), 13.20 μ.

Anal. Calcd for $C_{10}H_7N_3O_4 \cdot H_2O$: C, 51.95; H, 3.05. Found: C, 51.68; H, 3.36.

Benzoylations.—Each of the four disodium salts described above was dissolved in water. To each solution cooled to 0–5° and stirred, was added gradually during 1 hr equivalent amounts of benzoyl chloride and 2 *N* NaOH solution. At the completion of reaction, the ferric chloride color tests were negative.

To the water solution was added 1.3 volumes of hexane–benzene (1:1) followed by an excess (about 1.5 equiv) of 5 *N* HCl. The solid which separated was collected on a filter, washed well, dried, and recrystallized.

3-Carboxypicolino(benzoylhydroxamic) Acid, 1c.—This compound was obtained in a yield of 79%: mp 138–140° dec; melting point after crystallization from ethyl acetate–hexane, 141–143° dec; second recrystallization, 144.5–145° dec; ir 3.12, 3.24–3.92 (b), 5.68 (ester), 5.91 (acid), 6.00 μ (amide), and 18 other bands.

Anal. Calcd for $C_{14}H_{10}N_2O_5$: C, 58.74; H, 3.52; N, 9.79. Found: C, 58.81; H, 3.73; N, 9.77.

3-Carboxyisonicotino(benzoylhydroxamic) Acid, 2c.—This compound was obtained in a yield of 78%, mp 171–172° dec. For analysis it was recrystallized from dimethylformamide–water and was dried *in vacuo* over P_2O_5, mp 173–174° dec. This is close to the melting point of **2b** but the mixture melting point of the two ranged from 163 to 175°. Compound **2c** is insoluble in water, benzene, ethyl acetate, and is recrystallized with difficulty from alcohol: ir 3.10, 5.70, 5.87, 5.98, 6.25, 6.85 (m), 8.00, 9.50 (b), 11.80, 14.00 μ.

Anal. Calcd for $C_{14}H_{10}N_2O_5$: C, 58.74; H, 3.52; N, 9.79. Found: C, 58.15; H, 3.82; N, 9.96.

3-Carboxy-2-pyrazine(benzoylcarbohydroxamic) Acid, 8b.—This compound was obtained as colorless needles after crystallization from ethanol–water in a yield of 62%, mp 151–152° dec, and was unchanged after drying for 12 hr at 80° *in vacuo* over P_2O_5. The compound is a hydrate. Its mixture melting point with **8a** hydrate was 139–142° dec; ir 2.80 (w), 3.15, 3.32, 5.65 (ester), 5.85 (acid), 5.95 μ (amide), and 16 other bands.

Anal. Calcd for $C_{13}H_9N_3O_5 \cdot H_2O$: C, 51.15; H, 3.63; N, 13.77; neut equiv, 305.2. Found: C, 51.33; H, 3.73; N, 13.68; neut equiv, 302.0.

Dehydration of the Hydrate.—A mixture of 10 ml of toluene and 0.5 g of **8b** hydrate was refluxed for 15 min, then half of the toluene was distilled. The resulting solid (0.35 g) melted at 163–164° dec and gave mmp 159–161° with the monohydrate.

Anal. Calcd for $C_{13}H_9N_3O_5$: neut equiv, 287.2. Found: neut equiv, 290.6.

3-Carboxy-2-quinoxaline(benzoylhydroxamic) Acid, 9b.—Yield was 67% after recrystallization from ethyl acetate–hexane, mp 168–170° dec. The analytical sample was again recrystallized and kept at 80° *in vacuo* for 17 hr: mp 170–171° ir 3.00 (b), 5.70, 5.80, 5.29, 6.20 (m) μ, and 11 other bands.

Anal. Calcd for $C_{17}H_{11}N_3O_5$: C, 60.53; H, 3.29; N, 12.46; neut equiv, 337.3. Found: C, 60.45; H, 3.34; N, 12.46; neut equiv, 335.6.

Salts of the Benzoyl Derivatives.—Acids **1c**, **2c**, **8b**, and **9b** (0.5–1.5 g) were dissolved in methanol. Then 1 equiv of sodium, dissolved in methanol, was added. After cooling to 0°, ether–pentane (1:2) was added to complete the precipitation of the monosodium salts. The disodium salt of **1c** was made in the same way, using 2 equiv of CH_3ONa. The salts of **8b** and **9b** were methanolates, stable toward treatment *in vacuo* over P_2O_5 for 12 hr. Yields of monosodium salts were 86% from **1c** (92% for the disodium salt), 93% from **8b**, 82% from **9b**. The yield from **2c** was low (53%) because of the large volume of methanol required for solution. A 92% yield was obtained from 3 g of **2c** by dissolving it in 5 ml of warm dimethylformamide (*cf.* 80 ml of methanol), then at 15° adding 1 equiv of Na in 100 ml of metha-

(10) R. Wegschneider and A. Lipschitz, *Monatsh. Chem.*, **21**, 787 (1900); D. Cram and F. Elhafez, *J. Amer. Chem. Soc.*, **74**, 5846 (1952).

(11) K. Kaas, *Monatsh. Chem.*, **23**, 250 (1902).

nol, and completing the precipitation of the salt at 0° by use of dry ether. All compounds gave satisfactory analytical values for Na, including the methanolates **8b** and **9b**.

Rearrangement of Disodium 3-Carboxypicolinohydroxamate with Benzenesulfonyl Chloride.—To a solution of the disodium salt of **1b** in 30 ml of water (2°) was added 8 ml of 15% NaOH; 7.1 g of benzenesulfonyl chloride was then added dropwise. After stirring at 20–25° for 1 hr, the aqueous layer was extracted with 20 ml of benzene and was acidified (HCl) to pH 5. A precipitate (0.76 g) of 2-aminonicotinic acid formed on cooling: mp 290° dec (block) after recrystallization from water. It was identical with that obtained below.

Rearrangements of Monosodium Salts of 1c, 2c, 8b, and 9b in Water.—Samples of 1–2 g of the salts were dissolved in 10–30 ml of water and heated at 100° for 30–60 min. After cooling the solutions, 1 equiv of dilute HCl was added. The solid which formed was filtered off, dried, and extracted with benzene to remove benzoic acid. The remaining amino acid was recrystallized.

From **1c** was obtained 54% 2-aminonicotinic acid, mp 286–287° dec (see below); from **2c**, a 46% yield of 4-aminonicotinic acid,[12] melting point taken on a melting block, 338–341° dec; from **9b**, an 86% yield of 3-amino-2-quinoxalinecarboxylic acid,[13] mp 210° dec. The salt from **8b** (2 g) was largely unchanged after boiling the solution for 3 min. After acidification, 1.2 g of **8b** hydrate separated.

Rearrangements of Monosodium Salts in Toluene. 2-(Carboxyamino)nicotinic Cyclic Anhydride (3) from 1c.—Heating a suspension of 1 g of the Na salt of **1c** in 20 ml of dry toluene at 100° for 1 hr caused evolution of CO_2 [detected by $Ba(OH)_2$ solution]. After cooling and filtering, the residue was rinsed with benzene and extracted with warm water. The undissolved part was 0.19 g of **3** or 36%, mp 208–210° dec. Beckwith and Hickman[4] report mp 217–219° for **3**, recrystallization solvent unspecified. Our compound possessed the same four ir bands which they reported (Nujol mull, 3.18, 3.25, 5.42, 5.65 μ) and our spectrum (KBr) showed these additional bands: 5.70, 6.20, 6.55 (w), 7.00, 7.40, 7.80 (m), 8.10 (m), 9.70, 10.10, 10.75 (m), 12.00 (w), 12.70, 13.30, 14.00, 14.60 (w), 15.00 (m) μ. Our product was insoluble in benzene, ethyl acetate, or chloroform; attempted recrystallizations were unsuccessful.

When **3** was heated in water, 2-aminonicotinic acid separated, mp 287–290° dec. After heating in methanol, concentrating this solution, adding water, and cooling, methyl 2-aminonicotinate[14] separated, mp 84.5–85°, ir 5.92 μ.

The toluene filtrate from **3** was acidified, evaporated to dryness, and extracted with benzene to remove 0.25 g of benzoic acid. Extraction of the remainder with water left 0.18 g (40%) of 2-aminonicotinic acid (**4a**). It was recrystallized from hot water and dried: mp 289–290° dec (block) with gradual heating, or 308–310° dec when heating was started at 300° (lit. values range from 295 to 310°; ir 3.10, 3.40 (b), 5.87 μ (carboxyl), and 8 other bands.

Anal. Calcd for $C_6H_6N_2O_2$: C, 52.17; H, 4.38; N, 20.29. Found: C, 52.00; H, 4.62; N, 20.47.

2-Phenyl-4H-pyrido[2,3-*d*][1,3]oxazin-4-one, 5.—A mixture of **4a** (0.5 g), dry pyridine (8 ml), benzene (12 ml), and benzoyl chloride (0.5 ml) was heated for 30 min at 60–70°. The resulting green solution was poured into water. After the usual work-up and recrystallization from cyclohexane, 0.4 g of **5** was obtained as colorless needles: mp 145–146°; ir 5.71, 6.19, 6.27 μ and 11 other bands.

Anal. Calcd for $C_{13}H_8N_2O_2$: C, 69.64; H, 3.59; Found: C, 69.27; H, 3.70.

4-Aminonicotinic Acid (7a) from 2c.—A suspension of 2.68 g of the monosodium salt of **2c** in 60 ml of dry toluene was refluxed for 2 hr. Some CO_2 was evolved. The solid, presumably mainly **6**, was collected. It dissolved completely in 10 ml of water with gas evolution (CO_2). After acidifying and extraction with ether, 0.72 g (59%) of **7a**, mp 333–335° dec (block) was obtained. Crystallization from water gave fine needles: mp 338–340° (lit.[12] 340° dec); ir 3.05, 3.20, 4.00 (b), 6.00, 6.10, 6.40, 7.10, 7.50, 8.72 (m), 9.20 (w), 9.75 (w), 10.90 (w), 11.80 (m), 12.30 (m), 14.70 (b) μ.

Rearrangement in Toluene–Methanol.—Refluxing 1.0 g of the monosodium salt of **2c** in 40 ml of dry toluene and 5 ml of absolute methanol for 7 hr, then filtration and evaporation of the filtrate left a residue which was crystallized from alcohol–water to give 0.3 g of **7b**, mp 172–173°, lit.[12] mp 173°.

Methyl 3-Amino-2-pyrazinecarboxylate (10) from 8b.—A suspension of the monosodium salt of **8b**-methanolate and 30 ml of toluene was heated at reflux for 3 hr (CO_2 was evolved). The mixture was filtered and the filtrate was evaporated. The yellow residue (0.55 g, 40%) was crystallized from 95% ethanol yielding long yellow needles of **10**: mp 171–172°;[15] ir 2.90, 5.90 μ. Treatment with ammonia gave the amide, mp 237–238° (lit.[15] 239°). The toluene-insoluble residue gave 0.29 g (24%) of 3-amino-2-pyrazinecarboxylic acid [mp 208–210° dec (lit.[16] 210°); ir 2.92, 3.03, and 5.86 μ] after acidification and processing.

The sodium salt of **8b** rearranged comparably in refluxing xylene, giving methyl 3-amino-2-pyrazinecarboxylate (40%) and 3-amino-2-pyrazinecarboxylic acid (18%).

Rearrangement of 9b.—A suspension of 2.95 g of the monosodium salt methanolate of **9b** was refluxed in toluene for 3 hr. After filtration, the residue was acidified to give 0.9 g (63%) of 3-amino-2-quinoxalinecarboxylic acid:[13] mp 209–211° dec after recrystallization from acetic acid–water; ir 2.90 (m), 3.10 (m), 5.91 μ, and 8 other bands. Evaporation of the toluene filtrate left a residue that was recrystallized from methanol to give 0.52 g (33%) of **11**: mp 216–217° (lit.[13] mp 218–219°); ir: 2.87, 3.00, 5.88 μ, and 12 other bands.

N-Hydroxyquinolinimide, 12a.—Gentle heating of a suspension of 2.8 g of **1b** in 20 ml of thionyl chloride caused a vigorous reaction which subsided after 30 min. After refluxing for 30 min more, excess $SOCl_2$ was removed *in vacuo*. The residue was rinsed with benzene, air dried, and crystallized from 2-propanol; yield 2 g (80%), mp 229–230° dec. The compound gave no color with $FeCl_3$ but it instantly became bright red on addition of 2% NaOH solution, This color gradually disappeared on standing. For analysis, it was recrystallized from 2-propanol and dried *in vacuo* at 100° over P_2O_5: mp 230–231° dec; ir 3.80 (b), 5.55, 5.60, 5.80, 6.20 μ, and 10 other bands.

Anal. Calcd for $C_7H_4N_2O_3$: C, 51.22; H, 2.46; N, 17.07. Found: C, 51.51; H, 2.62; N, 16.83.

Quinolinic Anhydride and Hydroxylamine.—To an aqueous solution of 0.027 mol of hydroxylamine was added 0.025 mol of quinolinic anhydride. The solution was heated at 100° for 1 hr, then cooled. One gram (20%) of solid separated; this was shown to be **1c** by melting point and mixture melting point (163–164° dec) and ir spectrum. A further crop of product appeared to be a mixture of **1b** and quinolinic acid.

N-Benzoyloxyquinolinimide, 12b.—A precipitate formed at once as 0.3 ml of benzoyl chloride was added to a solution of 0.3 g of **12a** in 3 ml of dry pyridine. The mixture was heated 20 min at 60–70° (precipitate redissolved), then was cooled. The solid was removed, rinsed with 5% $NaHCO_3$ solution, dried, and crystallized from ethanol to form 0.35 g of fine needles: mp 156–157° (a second crystallization brought the melting point to 159–160°); ir 5.55 (w), 5.65, 5.75, 6.25 μ and, 8 other bands.

Anal. Calcd for $C_{14}H_8N_2O_4$: C, 62.69; H, 3.00. Found: C, 63.08; H, 3.22.

Compound **12b** was synthesized also in 82% yield by direct reaction of 2.6 g of **1c** and 15 ml of refluxing $SOCl_2$. After latter was removed under reduced pressure, the residue was rinsed with pentane, and crystallized from alcohol; 2 g of product was obtained, mp and mmp 157–158°.

3-Carboxypicolino(benzoylhydroxamic) Acid (1c) from 12a and Benzoyl Chloride.—To the intensely red suspension formed by adding 1.8 g of **12a** to a solution of 0.45 g of NaOH in 10 ml of water (2°) was added, with stirring, 1.6 g of benzoyl chloride during 20 min. The suspension became almost colorless. After 10 min more, another 0.4 ml of benzoyl chloride was added, the mixture was stirred for 30 min, and the now homogeneous mixture was acidified (HCl) to a congo red endpoint. The precipitate was collected, rinsed with both water and ether, dried, and crystallized from ethyl acetate–hexane to give 1.65 g (52%) of **1c**, mp 142–143°.

Rearrangement of 12b.—To a suspension of 2 g of **12b** in 20 ml of water at 10° was added 6 ml of 10% NaOH solution. When the solid had dissolved, the solution was heated at 100° for 45

(12) A. Kirpal, *Monatsh.*, **23**, 239 (1902); G. B. Bachman and R. Barker, *J. Org. Chem.*, **14**, 97 (1949). Both list 340° dec.

(13) A. Philips, *Ber.*, **28**, 1657 (1895) lists 210° dec; A. Gowenlock, G. Newbold, and F. Spring, *J. Chem. Soc.*, 622 (1945), list 212–213° dec.

(14) A. Kirpal, *Monatsh. Chem.*, **21**, 957 (1900); G. Koller, *Ber.*, **60**, 408 (1927).

(15) R. Ellington, R. Henry, and F. McDonald, *J. Amer. Chem. Soc.*, **67**, 1711 (1945).

(16) S. Gabriel and A. Sonn, *Ber.*, **40**, 4850 (1907).

min. Dilution with acetic acid and cooling produced a precipitate which was collected on a filter and extracted with ether. The residue was recrystallized from water yielding 0.45 g (43%) of 2-aminonicotinic acid, **4a**, mp 286–288° dec.

N-Hydroxycinchomeronimide, 14a.—The synthesis paralleled that of **12a**. From 1 g of **2b** and 8 ml of $SOCl_2$ was obtained 0.8 g of crude residue, insoluble in benzene. Crystallization from acetic acid gave 0.72 g (80%) of **14a**: mp 232–233° dec; ir 4.00 (b), 5.55, 5.60, 5.80, 6.20, 11.20, 14.00 μ.

Anal. Calcd for $C_7H_4N_2O_3$: C, 51.22; H, 2.46; N, 17.07. Found: C, 51.10; H, 2.75; N, 16.81.

N-Benzoyloxycinchomeronimide, 14b.—The method described for **12b** was followed; the warm reaction mixture was poured onto ice before collecting the solid product. From 0.3 g of **14a** was obtained 0.3 g (94%) of **14b**; after crystallization from ethanol, the melting point was 191–192°; ir 5.55 (w), 5.65, 5.75, 6.20 (m) μ, and 8 other bands.

Anal. Calcd for $C_{14}H_8N_2O_4$: C, 62.69; H, 3.00; N, 10.45. Found: C, 62.31; H, 2.94; N, 10.69.

The same compound was obtained in 83% yield from **2c** and thionyl chloride.

Rearrangement of 14b.—**14b** (1 g), insoluble in 10 ml of cold water, was brought into solution by 3 ml of 10% NaOH solution. After heating at 100° for 30 min, it was cooled and acidified (HCl) to pH 5. The precipitate was collected, dried, ether extracted to remove benzoic acid, and crystallized from water to yield 0.28 g (54%) of 3-aminoisonicotinic acid[7] (**15**), mp 299–302° dec (block). After another crystallization the melting point was 307–309° dec; ir 3.00, 3.10, 4.10, 4.70 (b), 6.15, 6.28 μ, and 9 other bands. A mixture of this acid and 4-aminonicotinic acid (mp 340° dec) melted at 265–285° dec.

Registry No.—Sodium 2-(methoxycarbonyl)nicotinate, 23410-97-1; benzyl 3-carboxypicolinate, 23410-98-2; benzyl 2-carboxynicotinate, 23410-99-3; disodium 3-carboxypicolinohydroxamate, 23411-00-9; disodium 3-carboxy-2-pyrazinecarbohydramate, 23411-01-0; disodium 3-carboxy-2-quinoxalinecarbohydroxamate, 23411-02-1; **1b**, 23411-03-2; **1c**, 23411-04-3; **2b**, 23411-05-4; **2c**, 23411-06-5; **3**, 21038-63-1; **4a**, 5345-47-1; **5**, 23411-09-8; **8a**, 23411-10-1; **8b**, 23411-11-2; **9a**, 23411-12-3; **9b**, 23411-13-4; **12a**, 23439-87-4; **12b**, 23411-14-5; **14a**, 23439-88-5; **14b**, 23411-15-6.

Reactions of 2-Acetoacetylaminopyridines with Triethyl Orthoformate and Zinc Chloride

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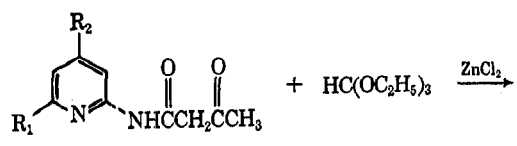
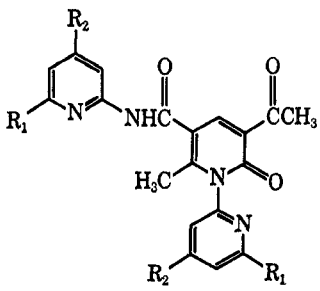
Received September 18, 1969

The reaction of 2-acetoacetylaminopyridines with triethyl orthoformate and zinc chloride did not yield the expected ethoxymethylene derivatives, but dimeric products, such as **2**, containing 2 mol of the starting material and one CH moiety. The scope of the reaction was explored. Mixed dimers were obtained upon addition of other acetoacetamides to the reaction mixture. A mechanism explaining these results is proposed.

In an attempt to prepare the ethoxymethylene derivative of 2-acetoacetylaminopyridine (**1**) by reaction with triethyl orthoformate, acetic anhydride, and zinc chloride, the condensation product **2** was obtained in modest yield. The yield could be raised to 69% by the use of ethanol instead of acetic anhydride as solvent; a much higher yield of the analogous product was obtained with the 6-methylpyridine **3**.

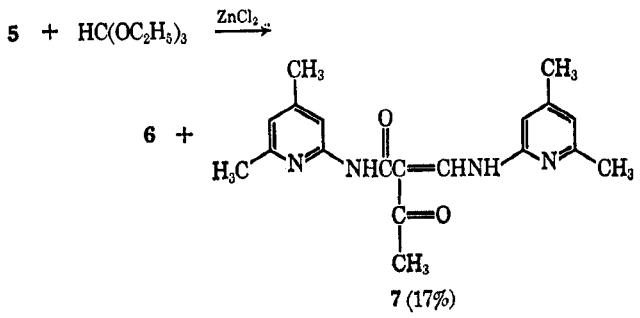


1, $R_1 = R_2 = H$
3, $R_1 = CH_3$; $R_2 = H$
5, $R_1 = R_2 = CH_3$



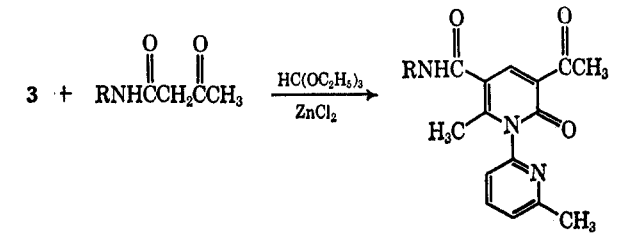
2, $R_1 = R_2 = H$ (69%)
4, $R_1 = CH_3$; $R_2 = H$ (91%)
6, $R_1 = R_2 = CH_3$ (12%)

Several 2-acetoacetylaminopyridines were used in this reaction (see Table I for details); 2-acetoacetylaminothiazole gave an analogous product. 2-Acetoacetylamino-4,6-dimethylpyridine was the only compound giving two isolable products. In addition to **6** (12%) a 17% yield of **7** was isolated.



7 (17%)

Addition of 2 mol of *p*-chloroacetoacetanilide to the reaction mixture gave rise to a mixed dimer. Compound **8** crystallized from the reaction mixture and was uncontaminated with a possible isomer or with **4**.



8, R = *p*-ClC_6H_4 (59%)
9, R = *n*-C_3H_7 (12%)
12, R = *t*-C_4H_9 (70%)