mixture of halide (0.1 mol), Li_2CuCl_4 (1–5 mol % to halide), and THF (50 mL) in 300-mL four-necked flask was added 1 (0.1 mol) in THF (100 mL) dropwise with stirring at the prescribed temperature under nitrogen atmosphere. An exothermic reaction occurred during the addition (in the cases of bromide, iodide), and the color of the contents gradually changed from reddish brown to black. After the completion of the addition, stirring was continued at the same temperature for the prescribed time interval.

The organic layer was separated after hydrolyzing the reaction mxiture with 6 N HCl, and the aqueous layer was extracted with two portions of diethyl ether (100 mL). The combined organic extract was washed first with 5 % aqueous sodium hydrogen carbonate and then with water, dried (Na_2SO_4), and distilled. The reaction products were identified by comparing their IR, MS, and NMR spectra with the reported data.[17,18] All the products gave reasonable elemental analyses.

Registry No. 1, 32657-89-9; *n*-$C_8H_{17}Br$, 111-83-1; *n*-$C_8H_{17}I$, 629-27-6; *n*-$C_8H_{17}Cl$, 111-85-3; *n*-$C_6H_{13}CH(CH_3)Br$, 557-35-7; *n*-$C_6H_{13}CH(CH_3)I$, 557-36-8; C_6H_5I, 591-50-4; C_6H_5Br, 108-86-1; *p*-BrC_6H_4I, 589-87-7; *p*-$ClC_6H_4CH_2Br$, 622-95-7; *p*-$BrC_6H_4CH_2Br$, 589-15-1; *p*-$BrC_6H_4CH_2CH_2I$, 85356-68-9; *p*-$IC_6H_4CH_2CH_2CH_2I$, 85356-69-0; $CH_3OCOCH_2CH_2I$, 5029-66-3; $C_2H_5OCO(CH_2)_3Br$, 2969-81-5; $CH_3OCO(CH_2)_3I$, 14273-85-9; $CH_3OCO(CH_2)_5I$, 14273-91-7; $ClCH_2CH_2CH_2Br$, 109-70-6; $BrCH_2CH_2CH_2CH_2Br$, 110-52-1; $C_6H_5COOCH_2CH_2I$, 39252-69-2; $HOCH_2CH_2I$, 624-76-0; $CH_3OCO(CH_2)_4I$, 14273-88-2; $NCCH_2CH_2CH_2Br$, 5332-06-9; $C_6H_5OCH_2CH_2Br$, 589-10-6; CuI, 7681-65-4; Li_2CuCl_4, 15489-27-7; $Pd(PPh_3)_4$, 14221-01-3; *i*-PrMgBr, 920-39-8; C_6H_5MgBr, 100-58-3; $CH_2{=}CHMgBr$, 1826-67-1; $CH_2{=}CHC(n\text{-}C_8H_{17}){=}CH_2$, 5732-02-5; $CH_2{=}CHC(CH(CH_3)\text{-}n\text{-}C_6H_{13}){=}CH_2$, 85356-70-3; $(CH_3)_2CH(CH_2)_7CH_3$, 6975-98-0; $C_6H_5(CH_2)_7CH_3$, 2189-60-8; $CH_2{=}CH(CH_2)_7CH_3$, 872-05-9; $CH_2{=}CHC(C_6H_5){=}CH_2$, 2288-18-8; $CH_2{=}CHC(C_6H_4Br\text{-}p){=}CH_2$, 38829-09-3; $CH_2{=}CHC(CH_2C_6H_4Cl\text{-}p){=}CH_2$, 85356-71-4; $CH_2{=}CHC(CH_2C_6H_4Br\text{-}p){=}CH_2$, 85356-72-5; $CH_2{=}CHC(CH_2CH_2C_6H_4Br\text{-}p){=}CH_2$, 85356-73-6; $CH_2{=}CHC(CH_2CH_2CH_2C_6H_4I\text{-}p){=}CH_2$, 85356-74-7; $CH_2{=}CHC(C_6H_4CH_2CH_2CH_2I\text{-}p){=}CH_2$, 85356-82-7; $CH_2{=}CHC(CH_2CH_2CH_2COOC_2H_5){=}CH_2$, 38049-11-5; $CH_2{=}CHC(CH_2CH_2CH_2COOCH_3){=}CH_2$, 85356-75-8; $CH_2{=}CHC(CH_2CH_2CH_2CH_2CH_2COOCH_3){=}CH_2$, 85356-76-9; $CH_2{=}CHC(CH_2CH_2CH_2Cl){=}CH_2$, 26831-14-1; $CH_2{=}CHC(CH_2CH_2CH_2CH_2Br){=}CH_2$, 85356-77-0; $CH_2{=}CHC(CH_2CH_2OCOC_6H_5){=}CH_2$, 85356-78-1; $CH_2{=}CHC(CH_2CH_2OH){=}CH_2$, 27974-99-8; $CH_2{=}CHC(CH_2CH_2CH_2CH_2COOCH_3){=}CH_2$, 85356-79-2; $CH_2{=}CHC(CH_2CH_2CH_2CN){=}CH_2$, 85356-80-5; $CH_2{=}CHC(CH_2CH_2OC_6H_5){=}CH_2$, 85356-81-6.

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2,4(3*H*,5*H*)-Furandione: Heteroannelations with Aromatic *o*-Amino Carbonyl Compounds and Condensations with Some *vic*-Polyones[1]

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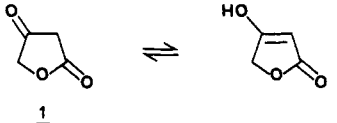
The chemical versatility of 2,4(3*H*,5*H*)-furandione (β-tetronic acid **1**) and its synthetic applicability are of con-

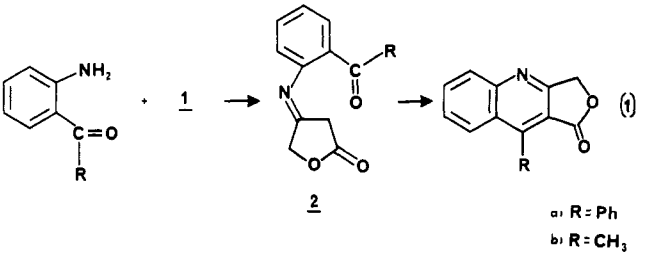


1

siderable current interest.[2] The multifunctional character of this small molecule confers an intriguing synthetic potential, which has prompted us to explore its chemistry. Recently, we reported the first facile synthesis of 3-(phenylmethylene)-2,4(3*H*,5*H*)-furandione by reaction of **1** with aromatic aldehydes[2s] and their conversion into the novel ring system 2,5-dihydrofuro[3,4-*d*]-1,2-oxaphosphol-4-(6*H*)-one.[2s] We now report the results of reactions of **1** with *o*-aminobenzophenones, aromatic *o*-amino aldehydes, and some 1,2,3-tricarbonyl compounds.

Results and Discussion

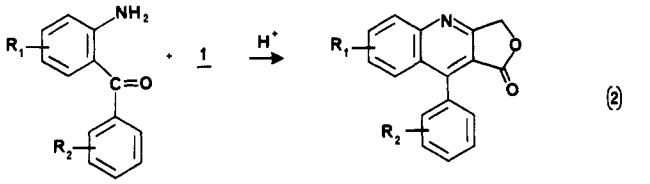
Heteroannelations of 1 with Aromatic *o*-Amino Carbonyl Compounds. Earlier workers[3] reported that a condensation of **1** with 2-aminobenzophenone gave β-(2-benzoylphenylimino)-γ-butyrolactone (**2**, eq 1). Cyclization of **2** afforded type **3** compounds. The conversion that we report here seems, however, more convenient since it eliminates the preparation and isolation of the intermediate anil. Further, we have demonstrated that the condensation affords **3** with a variety of substituents.



2

a, R = Ph
b, R = CH_3

The reaction of **1** with 1 equiv of a substituted 2-aminobenzophenone, in the absence of solvent and in the presence of concentrated HCl, effects in one pot a regioselective double condensation (eq 2) to form **3**. This



3
3a $R_1 = R_2 = H$
3b $R_1 = H$, $R_2 = 2\text{-}F$
3c $R_1 = 7\text{-}Cl$, $R_2 = H$
3d $R_1 = H$, $R_2 = 4\text{-}CH_3$

condensation proceeds successfully with either electron-withdrawing or electron-releasing substituents on the phenyl rings. For the compounds studied, isolated yields

(1) (a) This is part 31 of the series "Substituted γ-Butyrolactones". (b) For part 30 of this series see: Amer, A.; Ventura, M.; Zimmer, H. *J. Heterocycl. Chem.* **1983**, *19*, 359.

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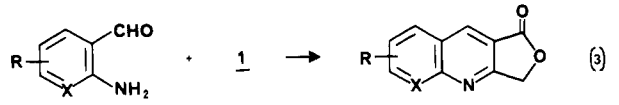
0022-3263/83/1948-1914$01.50/0

ranged from 51% to 81%. These nitrogen analogues of the antineoplastic lignan podophyllotoxin are high-melting solids and are easily characterized by their spectral data.

Similarly, with substituted aromatic *o*-amino aldehydes in ethanol solution, **1** reacts readily to give linearly condensed heterocyclic systems (eq 3). It is unnecessary to

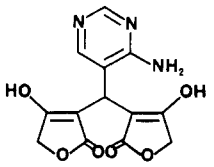


(3)

4

4a R = H, X = CH
4b R = 1,3-OCH_2O-, X = CH
4c R = H, X = N

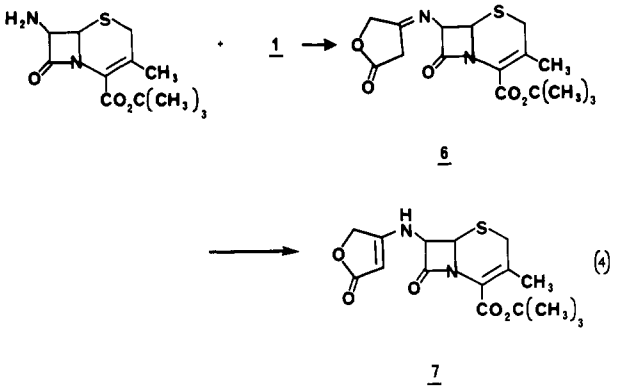
add acid or base to obtain an efficient condensation. The reaction of *o*-aminobenzaldehyde and 6-aminopiperonal with **1** provided furo[3,4-*b*]quinolin-1(3*H*)-one (**4a**) and 1,3-dioxolo[4,5-*g*]furo[3,4-*b*]quinolin-8(6*H*)-one (**4b**), respectively. Annelation of **1** with 2-amino-3-formylpyridine afforded the parent furo[3,4-*b*]naphthyridin-1(3*H*)-one ring system[4] (**4c**). The latter condensation represents a convenient entry into this previously unknown condensed ring system **4c**. In sharp contrast to the above results, 5-formyl-6-aminopyrimidine combined with **1** to give exclusively 3,3′-[(4-amino-5-pyrimidinyl)methylene]bis[4-hydroxy-2(5*H*)-furanone] (**5**). Formation of the 2:1 adduct



5

in preference to the 1:1 condensed heterocyclic system is attributed to the lack of nucleophilicity of the amino functionality in the 2-amino-3-formylpyrimidine.

As expected, aldehydic or keto carbonyl groups undergo condensation with the active methylene group of **1**, exclusively. In a further examination of the utility of **1**, the β-amino lactam *tert*-butyl cephamate reacted with **1** like a typical amine (eq 4). The product, **7**, results from



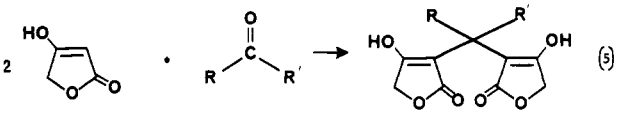
(4)

6

7

tautomerization of the initial Schiff base **6** to the isomeric enamine **7**.[5] The spectral data and combustion analysis are consistent with this structural assignment.

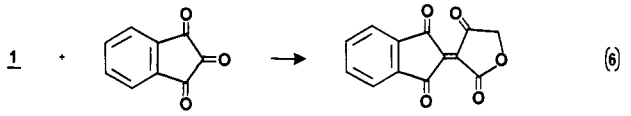
Condensations of 1 with *vic*-Polyones. According to previous reports,[6] **1** condensed with ketones to form 2:1 compounds of type **8** (eq 5; R = R′ = aliphatic and/or aromatic groups). It was of interest to explore the reaction



(5)

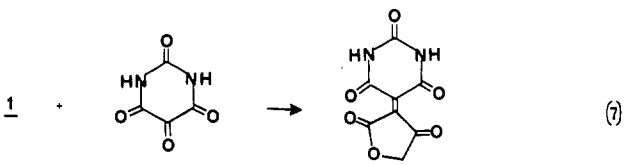
8

of **1** with *vic*-polyketones in an effort to obtain the first 1:1 condensation between **1** and a ketone carbonyl. For this investigation, the trione ninhydrin (1,2,3-indantrione, **9**), and the tetraone alloxan (**10**) were chosen. In contrast to other ketones,[6] **9** and **10** react with **1** in solution without acid or base to form the 1:1 adducts **11** and **12** to the exclusion of the bis tetronic acid product, even in the presence of excess **1** (eq 6 and 7). When β-tetronic acid



(6)

9 **11**



(7)

10 **12**

and **9** were combined in water in a 2:1 ratio, the 1:1 adduct **11** was obtained in 88% yield. Other ratios of **1** to ninhydrin gave lower isolated yields of **11** (1:1 ratio, 48%; 3:1, 77%). The assignment of the structure is based on elemental analysis, the ^1H NMR spectrum, and the H-decoupled ^{13}C NMR spectrum, which shows, as expected, nine lines.

Reaction of **10** with 2 equiv of **1** in water provided a 47% yield of the 1:1 adduct **12**. In anhydrous dimethoxyethane, isolation of the water-soluble product was greatly simplified, and an 81% yield of the monohydrate of **12** was isolated. In both cases only the central carbonyl group of the polyones reacted. This is in agreement with earlier observations of reactions between 1,2,3-triketones with species having an activated methylene group.[7] Again, the structural assignment is based on elemental analysis and easily interpretable ^1H and ^{13}C NMR data.

In conclusion, we have demonstrated the utility of **1** as a synthon for the elaboration of unique, fused-ring systems and its condensation behavior with *vic*-polyones. We are pursuing the study of **1** and its analogues with a focus on the further expansion of its synthetic utility to other classes of heterocyclic compounds.

Experimental Section

Infrared spectra (IR) were obtained on a Perkin-Elmer Model 599 spectrometer and were calibrated against the 1601-cm^{-1} band of polystyrene. Proton nuclear magnetic resonance spectra (^1H NMR) were recorded by using a Varian T-60 spectrometer. Chemical shifts are reported on the δ scale in parts per million downfield from tetramethylsilane, and apparent coupling constants (*J*) are given in hertz. Carbon-13 nuclear magnetic reso-

(4) Only a derivative of furo[3,2-*f*][1,7]naphthyridine is currently known. Nagano, Y.; Murakami, M. Japanese Kokai 75 35 194, 1975; *Chem. Abstr.* **1975**, *76*, 1474673.

(5) After cleavage with CF_3CO_2H, the free acid was checked for antibacterial activity but was found inactive. We express thanks to Dr. J. Dolfini and Dr. E. Boehme, Merrell-Dow National Laboratories, Cincinnati, OH, for these results.

(6) (a) Wolff, L. *Justus Liebigs Ann. Chem.* **1901**, *315*, 145. (b) Wolff, L. *Ibid.* **1896**, *291*, 226.

(7) (a) Schönberger, A.; Singer, E. *Chem. Ber.* **1970**, *103*, 3871. (b) Rubin, M. B. *Chem. Rev.* **1975**, *75*, 177.

nance data (^{13}C NMR) were obtained on a Varian CFT-20 instrument with Me_4Si as the internal standard. A Perkin-Elmer RMU-7 mass spectrometer was used to record mass spectral data at 70 eV. Melting points were determined by using a Mel-Temp melting point apparatus and are uncorrected. Microanalyses were performed by Galbraith Laboratories, Inc., Knoxville, TN, or by M-H-W Laboratories, Phoenix, AZ.

General Procedure for the Preparation of 9-Arylfuro[3,4-*b*]quinolin-1(3*H*)-ones 3a-d. To a melt of the appropriate 2-aminobenzophenone was added an equimolar amount of 1 and a few milliliters of concentrated hydrochloric acid. The mixture usually solidifies quickly upon cooling. Recrystallization from ethanol afforded the pure products (if necessary the hot solution was decolorized with Norit A).

9-Phenylfuro[3,4-*b*]quinolin-1(3*H*)-one (3a): yield 51%; mp 204-205 °C (lit.[3] mp 204-205 °C); ^1H NMR (Me_2SO-d_6 and $CDCl_3$) δ 5.6 (s, 2 H, CH_2), 7.0-8.4 (m, 9 H, aromatic H); IR (KBr) 1770 (C=O) cm^{-1}; mass spectrum, *m/e* (relative intensity) 261 (M^+, 100), 262 (M + 1, 19).

9-(2-Fluorophenyl)furo[3,4-*b*]quinolin-1(3*H*)-one (3b): yield 59.4%; mp 177-178 °C; ^1H NMR (Me_2SO-d_6) δ 5.6 (s, 2 H, CH_2), 7.08-8.48 (m, 8 H, aromatic H); IR (KBr) 1770 (C=O) cm^{-1}; mass spectrum, *m/e* (relative intensity) 279 (M^+, 100), 250 (M - 29, 72). Anal. Calcd for $C_{17}H_{10}FNO_2$: C, 73.11; H, 3.61; N, 5.02. Found: C, 72.88; H, 3.65; N, 4.99.

7-Chloro-9-phenylfuro[3,4-*b*]quinolin-1(3*H*)-one (3c): yield 80.8%; mp 281-282 °C; ^1H NMR δ 5.6 (s, 2 H, CH_2), 7.83-9.1 (m, 8 H, aromatic H); IR (KBr) 1770 (C=O) cm^{-1}; mass spectrum, *m/e* (relative intensity) 295 (M^+, 100), 297 (M + 2, 25). Anal. Calcd for $C_{17}H_{10}ClNO_2$: C, 69.04; H, 3.41; Cl, 11.99. Found: C, 68.81; H, 3.61; Cl, 12.33.

9-(4-Methylphenyl)furo[3,4-*b*]quinolin-1(3*H*)-one (3d): yield 64%; mp 226 °C; ^1H NMR (Me_2SO-d_6) δ 2.5 (s, 3 H, CH_3), 5.5 (s, 2 H, CH_2), 7.4-8.2 (m, 8 H, aromatic H); IR (KBr) 1780 (C=O) cm^{-1}; mass spectrum, *m/e* (relative intensity) 275 (M^+, 100), 276 (M + 1, 20). Anal. Calcd for $C_{18}H_{13}NO_2$: C, 78.53; H, 4.76; N, 5.09. Found: C, 78.60 H, 4.70; N, 4.89.

General Procedure for the Preparation of Furo[3,4-*b*]quinolin-1(3*H*)-ones 4a-c. Equivalent amounts of the appropriate 2-aminobenzaldehyde and 1 were dissolved in absolute ethanol and stirred at room temperature for several hours and monitored by TLC. (In the case of **4b** a few drops of conc. hydrochloric acid were added). The formed precipitate was filtered and recrystallized from acetonitrile (**4a**) or absolute ethanol (**4b**, **4c**).

Furo[3,4-*b*]quinolin-1(3*H*)-one (4a): yield 79%; mp 224-225 °C (lit.[3] mp 219-220 °C); ^1H NMR (Me_2SO-d_6) δ 5.60 (s, 2 H, CH_2), 7.60-8.53 (m, 4 H, aromatic H), 9.16 (s, 1 H, H at 9-position); IR (KBr) 1760 (C=O) cm^{-1}; mass spectrum, *m/e* (relative intensity) 185 (M^+, 61), 156 (M - 29, 100). Anal. Calcd for $C_{11}H_7NO_2$: C, 71.35; H, 3.81; N, 7.56. Found: C, 71.56; H, 3.86; N, 7.54.

1,3-Dioxolo[4,5-*g*]furo[3,4-*b*]quinolin-8(6*H*)-one (4b): yield 75.1% (crude); mp 284-285 °C; ^1H NMR (Me_2SO-d_6) δ 5.52 (s, 2 H, CH_2), 6.37 (s, 2 H, OCH_2O), 7.55 (d, 1 H, $J \simeq 1$ Hz, H at 4-position), 7.67 (d, 1 H, $J \simeq 1$ Hz, H at 10-position), 8.85 (s, 1 H, H at 9-position); IR (KBr), 1765 (C=O) cm^{-1}; mass spectrum, *m/e* (relative intensity) 229 (M^+, 88), 200 (M - 29, 100). Anal. Calcd for $C_{12}H_7NO_4$: C, 62.88; H, 3.08; N, 6.11. Found: C, 62.89; H, 2.88; N, 6.09.

Furo[3,4-*b*]naphthyridin-1(3*H*)-one (4c): yield 79%; mp 266-267 °C; ^1H NMR (Me_2SO-d_6) δ 5.65 (s, 2 H, CH_2), 7.73-9.32 (m, 4 H, aromatic H); IR (KBr) 1760 (C=O) cm^{-1}; mass spectrum, *m/e* 186 (M^+), 157 (M - 29). Anal. Calcd for $C_{10}H_6N_2O_2$: C, 64.51; H, 3.52; N, 15.05. Found: C, 64.42; H, 3.34; N, 14.93.

3,3'-[(4-Amino-5-pyrimidinyl)methylene]bis[4-hydroxy-2(5*H*)-furanone] (5). To 4-amino-5-formylpyrimidine (0.308 g, 2.5 mmol) dissolved in refluxing 2-propanol (10 mL) was added 1 (0.250 g, 2.5 mmol). A clear solution resulted; then, within a few minutes a precipitate began to form. After being refluxed for 1 h, the reaction mixture was cooled to room temperature. The precipitate was isolated by filtration and washed with hot 2-propanol and with hot acetonitrile to give the bis adduct: 0.351 g (92%); mp >300 °C (the substance slowly darkens and chars with heating); ^1H NMR (Me_2SO-d_6) δ 4.33 (s, 1 H, ≥C-CH-C≤, 4.52 (s, 4 H, CH_2), 8.06 (br s, 1 H, aromatic H), 8.73 (br s, 1 H, aromatic H), 9.1 (br s, 2 H, NH_2, D_2O exchangeable), 11.75 (br s, 2 H, C=COH, D_2O exchangeable); IR (KBr) 3365, (NH_2), 3165-3135 (enolic OH), 1730 (C=O) cm^{-1}; mass spectrum, *m/e* (relative intensity) 205 (M - 100, 10), 187 (M - 118, 100). Anal. Calcd for $C_{13}H_{11}N_3O_6$: C, 51.15, H, 3.65; N, 13.77. Found: C, 51.24; H, 3.80; N, 13.49.

***tert*-Butyl 7-[(2,5-Dihydro-5-oxo-2-furanyl)amino]-3-methyl-8-oxo-5-thia-1-azabicyclo[4.2.0]oct-2-ene-2-carboxylate (7).** To a stirred solution of the *tert*-butyl ester of cephamic acid (0.2702 g, 10 mmol) in absolute ethanol was added 1 (1.00 g, 10 mmol). Initial crystal formation occured after 40 h, but stirring was continued for an additional 16 h. Filtration and recrystallization from methanol gave 7 as colorless crystals: 0.1127 g (32 %); mp 215-216 °C; ^1H NMR ($CDCl_3$ and Me_2SO-d_6) δ 1.5 (s, 9 H, $C(CH_3)_3$), 2.03 (s, 3 H, CH_3), 3.5 (d, 2 H, J = 6 Hz, OCH_2), 4.6-5.7 (m, 5 H), 8.2 (d, 1 H, $J \simeq 6$ Hz, NH, D_2O exchangeable); IR (KBr) 3225 (NH), 1740, 1730, 1710, (3 C=O) cm^{-1}. Anal. Calcd for $C_{16}H_{20}N_2O_5S$: C, 54.53; H, 5.72; N, 7.95. Found: C, 54.17; H, 5.56; N, 7.89.

3-(1,3-Dihydro-1,3-dioxo-2*H*-inden-2-ylidene)-2,4-(3*H*,5*H*)-furandione Dihydrate (11). Combined with stirring in water were ninhydrin monohydrate (0.891 g, 5 mmol) and 1 (1.00 g, 10 mmol). Precipitation of product began quickly. After 15 min, TLC of the supernatant indicated complete reaction. The precipitate was isolated by filtration, washed generously with water, and dried at 80 °C in vacuo over P_4O_{10}. The yield of analytically pure product was 1.23 g (88.4%): mp 175-176 °C; ^1H NMR (Me_2SO-d_6) δ 4.76 (s, 2 H), 8.07 (s, 4 H), 8.78 (br s, 4 H, D_2O exchangeable); ^{13}C NMR (Me_2SO-d_6) δ 67.6 (CH_2, t), 74.8 (s), 95.7 (s), 123.5, (aromatic, d), 136.6 (aromatic, d), 140.1 (aromatic), 172.0, (s, C=O), 177.6 (s, C=O), 197.7 (s, C=O); IR (KBr) 3450 (H_2O), 1740, 1720 (2 C=O) cm^{-1}. Anal. Calcd for $C_{13}H_6O_5 \cdot 2H_2O$: C, 56.12; H, 3.62. Found: C, 55.88; H, 3.23.

5-(4,5-Dihydro-2,4-dioxo-3(2*H*)-furanylidene)-2,4,6-(1*H*,3*H*,5*H*)-pyrimidinetrione Monohydrate (12). Combined in anhydrous dimethoxyethane (DME, distilled from CaH_2, 10 mL) were alloxan monohydrate (1.60 g, 10 mmol) and 1 (2.00 g, 20 mmol). While the reaction mixture was stirred, a white precipitate formed. After 3 days at room temperature, the solid was removed by filtration, washed with DME, and dried at 80 °C in vacuo over P_4O_{10}: yield 1.97 g (81%); mp, foams at 204 °C then slowly deocmposes with increasing temperature; ^1H NMR (Me_2SO-d_6) δ 4.77 (s, 2 H, CH_2), 9.03 (br s, 2 H), 11.47 (s, 2 H, both D_2O exchangeable); ^{13}C NMR (Me_2SO-d_6) δ 67.3 (t, CH_2), 71.5 (s, C=C), 96.5 (s, C=C), 149.7 (s, C=O), 169.2 (s, C=O), 171.9 (s, C=O), 177.0 (s, C=O); IR (KBr) 3420, 3410, 3070, 2870 (H_2O, NH), 1705 (C=O), 1410 cm^{-1}. Anal. Calcd for $C_8H_4N_2O_6 \cdot H_2O$: C, 39.68; H, 2.50; N, 11.66. Found: C, 39.69; H, 2.51; N, 11.66.

Registry No. 1, 4971-56-6; **3a**, 85422-43-1; **3b**, 85422-44-2; **3c**, 85422-45-3; **3d**, 85422-46-4; **4a**, 4945-38-4; **4b**, 6720-24-7; **4c**, 85422-47-5; **5**, 85422-48-6; **7**, 85422-49-7; **9**, 938-24-9; **10**, 50-71-5; **11**, 85422-50-0; **12**, 85422-51-1; *o*-aminobenzophenone, 2835-77-0; 2-amino-2'-fluorobenzophenone, 1581-13-1; 2-amino-5-chlorobenzophenone, 719-59-5; 2-amino-4'-methylbenzophenone, 36192-63-9; *o*-aminobenzaldehyde, 529-23-7; *o*-aminopiperonal, 23126-68-3; 2-amino-3-formylpyridine, 7521-41-7; 5-formyl-6-aminopyrimidine, 16357-83-8; *tert*-butyl cephamate, 33610-06-9.

Sodium-Liquid Ammonia Reduction of Carboxamides to Alcohols

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A partial reduction of amides of simple carboxylic acids to alcohols in liquid NH_3 by Na was first reported in 1912;[1,2] however, this reaction as a source of side reactions

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