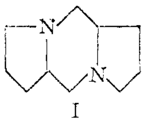
alcohols react with the amine at comparable rates, two products are possible, N-butyl-2-hydroxymethylpyrrolidine and decahydrodipyrrolo[a,d]pyrazine (I).


I

Compound I may be thought of as arising from ring closure between two molecules of 2-hydroxymethylpyrrolidine, the amino group of each being alkylated by the hydroxyl group of the other. The over-all reaction is another example of reductive cyclization, a concept employed in syntheses of the octahydropyrrocoline nucleus[6] and 1-azabicyclo compounds.[7]

Two products were actually isolated from the reaction mixture resulting when butyl pyroglutamate was hydrogenated over copper-chromium oxide at 250°. One, a white crystalline solid, exhibited a titration curve corresponding to a diamine of molecular weight 167 (theory for Compound I, 166); its elementary analysis was in good agreement with that calculated for decahydrodipyrrolo[a,d]pyrazine. The other product was a liquid exhibiting the titration curve of a monoamine of molecular weight 152 (theory for N-butyl-2-hydroxymethylpyrrolidine, 157).

If the line of reasoning outlined above is correct, hydrogenation in the absence of butanol should eliminate the formation of N-butyl-2-hydroxymethylpyrrolidine and correspondingly increase the yield of decahydrodipyrrolo[a,d]pyrazine. This conclusion was confirmed by experiment. Since the hydrogenation of butyl pyroglutamate occurs stepwise, it was possible to prevent butylation. Butyl pyroglutamate was hydrogenated in dioxane at 150°, the solvent was completely removed by distillation and hydrogenation was completed at 250° in fresh dioxane. By this procedure the yield of decahydrodipyrrolo[a,d]pyrazine was almost tripled. Furthermore, when a sample of pure 5-hydroxymethyl-2-pyrrolidone was hydrogenated, the yield of decahydrodipyrrolo[a,d]pyrazine was practically quantitative.

Experimental

Dioxane used as reaction medium was purified according to the method of Fieser.[8] Catalyst was prepared as described by Riener.[9] Hydrogenations were effected in a 480-ml. stainless steel bomb at a hydrogen pressure of 2000–3000 p.s.i.

Butyl Pyroglutamate.—Two moles of commercial glutamic acid, 16 moles of butanol and 2.5 moles of sulfuric acid were refluxed for 9 hours. The refluxing liquid was fractionated through an 18" silvered vacuum-jacketed column, and the water phase was continuously collected and removed. The reaction mixture was brought to *p*H 4.5 with 1 *M* Na_2CO_3, stripped of butanol *in vacuo*, and then brought to *p*H 9.5 with 5 *N* NaOH while being stirred with 1000 ml. of benzene. The aqueous phase was extracted with three 500-ml. portions of benzene. The combined benzene solution was washed with saturated NaCl solution and distilled through a 6" Vigreux column. Crude product was collected between 158–163° (1.0 mm.). Redistillation gave 242 g. (65% yield), b.p. 157–160° (1.3 mm.).

Anal. Calcd. for $C_9H_{15}NO_3$: N, 7.56. Found: N, 7.39.

5-Hydroxymethyl-2-pyrrolidone.—Thirty-seven grams (0.2 mole) of butyl pyroglutamate in 125 ml. of dioxane was hydrogenated over 18.5 g. of copper-chromium oxide at 150° for 4 hours. The pressure dropped 820 lb. in the first 3 hours and 10 lb. in the last hour. Catalyst was removed by filtration. Titration of an aliquot of the filtrate demonstrated the absence of amino nitrogen. Solvent was distilled *in vacuo*, leaving a residue which readily crystallized; yield 21.5 g. (96%), m.p. 76–78°; recrystallized from benzene, 16 g., m.p. 84–85°.

One-step Hydrogenation of Butyl Pyroglutamate.—Butyl pyroglutamate (37.0 g., 0.2 mole) in 150 ml. of dioxane was hydrogenated over 18.5 g. of copper-chromium oxide at 250° for 5.5 hours. Catalyst and solvent were removed. The residue (20.0 g.) was set in a refrigerator overnight.

Crystals which formed were collected on a buchner funnel; wt. 4.5 g. (27%), m.p. 69–77°. Recrystallization from hexane brought the m.p. to 84.0–84.5°; this solid did not depress the m.p. of an analyzed sample of decahydrodipyrrolo[a,d]pyrazine.

The filtrate remaining after the solid was filtered from the reaction mixture was distilled through a 3" Vigreux column; yield 6.0 g. (19%), b.p. 70–73° (1.2 mm.). Its titration curve corresponded closely to that expected for N-butyl-2-hydroxymethylpyrrolidine.

Anal. Calcd. for $C_9H_{19}NO$: N, 8.8. Found: N, 8.0.

Two-step Hydrogenation of Butyl Pyroglutamate.—Hydrogenation was effected as in the one-step process, but for 4.5 hours at 150°. Catalyst was filtered off and solvent was completely removed from the filtrate by vacuum distillation. The residue (21.1 g.) was hydrogenated for 5.5 hours at 250° in 150 ml. of dioxane over 21.1 g. of copper-chromium oxide. Catalyst and solvent were again removed. The residue was a white crystalline solid; yield 12.8 g. (77%), m.p. 77–80°. Two recrystallizations from hexane raised the m.p. to 84.0–84.5°; the m.p. was unchanged by an additional crystallization.

Anal. Calcd. for $C_{10}H_{18}N_2$: C, 72.26; H, 10.90; N, 16.85. Found: C, 72.43; H, 10.45; N, 17.22.

Hydrogenation of 5-Hydroxymethyl-2-pyrrolidone.—A mixture of 1.4 g. of 5-hydroxymethyl-2-pyrrolidone, 0.7 g. of copper-chromium oxide and 25 ml. of dioxane was hydrogenated for 5.5 hours at 250°. The product was isolated in the usual way; yield 1.0 g. (100%), m.p. 81–82°, mixed m.p. with an analyzed sample, 82.0–82.5°.

GEORGE M. MOFFETT RESEARCH LABORATORIES
CORN PRODUCTS REFINING COMPANY
ARGO, ILLINOIS

RECEIVED JULY 27, 1951

---

[6] N. J. Leonard and J. H. Boyer, THIS JOURNAL, **72**, 2980 (1950).

[7] N. J. Leonard and W. E. Goode, *ibid.*, **72**, 5404 (1950).

[8] L. F. Fieser, "Experiments in Organic Chemistry," 2nd Ed., D. C. Heath and Co., New York, N. Y., 1941, p. 369.

[9] T. W. Riener, THIS JOURNAL, **71**, 1130 (1949).

The Preparation of High Purity Silver Chloride

BY WILLIAM ZIMMERMAN, III

Silver chloride containing <0.001% metallic impurities was prepared in large quantities for the growth of single crystals used in plastic flow, solarization and recrystallization studies. Reagent grade AgCl was not sufficiently pure and although a method[1] was available which gave a product containing <0.02% metallic impurities, this method was laborious and time consuming and the product dried to a cake which was difficult to manipulate. The procedure described here gave a granular, easily washed product which dried with the minimum formation of lumps. No single metallic impurity exceeded 0.001%. Reagent grade chemicals were used throughout and were checked spectrographically to determine impurities which might be introduced during preparation. Ammonium hydroxide showed about 0.25% SiO_2,

---

[1] R. N. Maxson, "Inorganic Syntheses," Vol. I, McGraw-Hill Book Co., Inc., New York, N. Y., 1939, pp. 2-4.

80% of which was removed by filtration. The balance did not interfere since <0.001% SiO_2 was found in the product. All filtrations were carried out in fritted-glass funnels, since any filter paper shreds in the final product caused reduction of AgCl during single crystal growth. Scrap silver salts, washed free of oil and grease with petroleum ether, reagent grade silver salts and silver metal were used as starting materials.

Experimental

The silver salts[2] were reduced with granular zinc (20 mesh, low in As, Fe and Pb) in (1:10) HCl, and the resulting metal was washed thoroughly, first by decantation, and then by filtration. The metallic silver was dissolved in a minimum amount of dilute (1:1) HNO_3. The resulting solution was diluted and tin, antimony, and the insoluble chlorides allowed to settle out. After filtration, the solution was heated, made ammoniacal, and filtered, removing Fe, Al, most of the Tl and some of the SiO_2. The filtrate was made just acid with HNO_3 and evaporated to a small volume, cooled, filtered and the resulting $AgNO_3$ was dissolved in water and filtered. AgCl was precipitated from the filtrate with concentrated HCl in slight excess.[3] After filtration, AgCl was dissolved in a minimum amount of NH_4OH and any residue filtered off. The solution was gently heated with continuous stirring until crystallization began. Removed from the heat, the solution was placed in the dark. Vigorous stirring was continued to prevent formation of a crust and to allow NH_3 to escape. After a sufficient crop of crystals had formed, they were washed, first with water, then with HCl and finally with water. The solution was reheated and a second and third crop of crystals gathered in the same manner. Proper care was taken throughout to recover silver from filtrates and residues.

[2] Silver metal was dissolved in a minimum amount of HNO_3; AgCl was precipitated and washed free of nitrates, then treated as above.

[3] When thallium was present in excess of 0.50%, repetition of the preceding steps was necessary; and when copper was present in large quantities, repetition was deemed advisable.

CRYSTAL BRANCH, METALLURGY DIVISION
NAVAL RESEARCH LABORATORY
WASHINGTON, D. C.
RECEIVED OCTOBER 1, 1951

NEW COMPOUNDS

Preparation of N-Acetylphenyl-2-thienylamine[1,2]

Ten grams (0.075 mole) of acetanilide, 20 g. (0.123 mole) of 2-bromothiophene, 5 g. (0.037 mole) of anhydrous potassium carbonate, about 0.1 g. of a mixture of powdered potassium iodide and powdered copper, a crystal of iodine and 50 ml. of nitrobenzene[3] were stirred in a three-necked 250-ml. flask in a nitrogen atmosphere for 25 hours at 160–170°. The dark mixture was neutralized, steam distilled and the residue cooled. The oil layer was extracted with ether, the ether solution dried with calcium chloride, and the ether removed by vacuum distillation at 100°. The solid, which weighed 14 g., was washed with 50 ml. of Skellysolve A, then dissolved in 25 ml. of hot absolute ethanol, treated with Norite A and filtered. The crystals which separated on cooling were collected on a filter and dissolved in 400 ml. of boiling water by addition of the minimum amount of ethyl alcohol. The precipitate which separated on cooling was collected on a filter and dried in vacuum over sulfuric acid, yielding 2.2 g. (14%) of white crystals melting at 100–101°.

Anal. Calcd. for $C_{12}H_{11}ONS$: N, 6.44; S, 14.74. Found: N, 6.33; S, 14.76.

Experimental conditions sufficiently vigorous to cause hydrolysis of N-acetylphenyl-2-thienylamine invariably resulted in formation of tars.

When 2-iodothiophene was substituted for 2-bromothiophene in the above procedure, a yield of 2.5 g. (31%) of crude N-acetyl phenyl 2-thienylamine was obtained. When 2-chlorothiophene was used, no product was obtained. Use of the method with N-acetyl-2-aminothiophene and iodobenzene gave less than a gram of crude N-acetyl phenyl 2-thienylamine. From N-acetyl-2-aminothiophene and 2-bromothiophene no acetyl-di-2-thienylamine could be obtained.

[1] From the M.S. thesis of Peter Panzera, June, 1949.

[2] This work was supported in part by a Research Corporation Grant-in-aid.

[3] I. Goldberg, *Ber.*, **40**, 4541 (1907).

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF KENTUCKY
LEXINGTON, KENTUCKY
REEDUS RAY ESTES
PETER PANZERA
RECEIVED OCTOBER 15, 1951

Preparation of Ethyl Pyrazinoylacetate

A mixture of 13.8 g. of methyl pyrazinoate and 14.8 g. of ethyl acetate was added slowly with stirring to 10.7 g. of alcohol-free sodium ethoxide. After standing at room temperature for one hour, the mixture was refluxed for five hours. The reaction mixture was then cooled, dissolved in 125 ml. of water and extracted with ether to remove the unreacted esters. The solution was neutralized to a *p*H of 7 with hydrochloric acid and exhaustively extracted with ether. The ether extract was dried over sodium sulfate and evaporated to a small volume to give 13 g. (67%) of ethyl pyrazinoylacetate (yellow crystals), which melted at 66–67° when recrystallized from petroleum ether.

Anal. Calcd. for $C_9H_{10}O_3N_2$: C, 55.6; H, 5.15; N, 14.4. Found: C, 55.7; H, 5.28; N, 14.4.

The following derivatives of ethyl pyrazinoylacetate were prepared: 2,4-dinitrophenylhydrazone, yellow crystals which melted at 187–189° when recrystallized from ethanol.

Anal. Calcd. for $C_{15}H_{16}O_6N_6$: N, 22.5. Found: N (Dumas), 22.8.

Phenylhydrazone, yellow crystals which melted at 131–132° when recrystallized from ethanol.

Anal. Calcd. for $C_{15}H_{16}N_4O_2$: N, 19.7. Found: N (Dumas), 19.5.

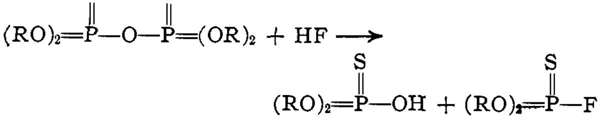
3-(2-Pyrazyl)-pyrazolone-5 light tan crystals which melted with decomposition at 245–246° when recrystallized from methanol.

Anal. Calcd. for $C_7H_6N_4O$: N, 34.6. Found: N (Dumas), 34.6.

NEPERA CHEMICAL CO., INC.
NEPERA PARK
YONKERS, NEW YORK
T. I. FAND
DEPARTMENT OF CHEMISTRY
POLYTECHNIC INSTITUTE OF BROOKLYN
BROOKLYN, N. Y.
P. E. SPOERRI
RECEIVED OCTOBER 5, 1951

Diethylthionomonofluorophosphate

The preparation of dialkylmonofluorophosphoric esters, $(RO)_2POF$, by the interaction of anhydrous hydrogen fluoride with symmetrical pyrophosphoric acid diesters has been previously described.[1] A similar procedure has now been found satisfactory for obtaining analogous thioesters. The general reaction is



$$(RO)_2{=}\overset{S}{\overset{\|}{P}}{-}O{-}\overset{S}{\overset{\|}{P}}{=}(OR)_2 + HF \longrightarrow (RO)_2{=}\overset{S}{\overset{\|}{P}}{-}OH + (RO)_2{=}\overset{S}{\overset{\|}{P}}{-}F$$

The higher volatility of the fluoro-ester permits its separation by fractional distillation from the acid ester.

To 7.8 g. of anhydrous hydrogen fluoride in a platinum bottle cooled in ice 101.2 g. of tetraethyldithionopyrophosphate[2] was slowly added. In spite of some vaporization

[1] A. Hood and W. Lange, THIS JOURNAL, **72**, 4956 (1950).

[2] The tetraethyldithionopyrophosphate was kindly supplied by the Victor Chemical Works. For description of this and related compounds, see A. D. F. Toy, *ibid.*, **73**, 4670 (1951).