Acid Isomerization.—The **picric acid columns** were used for four repeated injections of the same sample of 7-methyltropilidene. Portions of each successive eluate were retained for subsequent analysis on the nitromethylpimelonitrile column. Analysis showed that isomerization proceeded progressively and that changes were still observed during the last pass. The use of solvent (pentane) to facilitate handling of the small amounts of material collected made the peaks broad in the final analyses so that accurate quantitative isomer distributions could not be obtained, but the 7, 2, 3, and 1 isomers were about 63:8:9:19 from the picric acid–fluorene column. Isomerization went faster (final ratio after four injections about 36:11:8:45) on the picric acid–dioctyl phthalate column than on the picric acid–fluorene column, presumably because the retention time was much larger on the former so that the tropilidenes were exposed to picric acid for a longer period of time.

The **phosphoric acid column** gave results very similar to those obtained with the picric acid columns, except that the isomerization appeared still more rapid, and was more nearly complete at the end of four successive passes (ratio was about 6:13:24:57) of the same sample through the column. Once again, accurate analyses of the eluted materials were not obtained.

Hydride Exchanges.—The picric acid–fluorene column which had been prepared and used 3 years ago was again used. After the above isomerizations were studied and several injections of 7-methyltropilidene had been made, injection of 5 μl. of unsubstituted tropilidene and subsequent analysis of the collected eluate on the nitromethylpimelonitrile column gave evidence for the presence of about 1.6% of 1-methyltropilidene in the tropilidene sample which was collected.

The **tropylium fluoroborate–nitromethylpimelonitrile column** (which was prepared by coating the firebrick from an acetonitrile solution of the stationary phases and handling rapidly to minimize exposure to air) was used promptly after it was baked out with a helium stream overnight. The samples eluted from each of three 5-μl. injections of 7-methyltropilidene were analyzed on an SF-90 column and proved to be unsubstituted tropilidene with no discernible quantitity of methyltropilidenes present.

Low-Pressure Catalytic Hydrogenation of Some 1-(Tertiary amino)-2-methyl-2-nitropropanes

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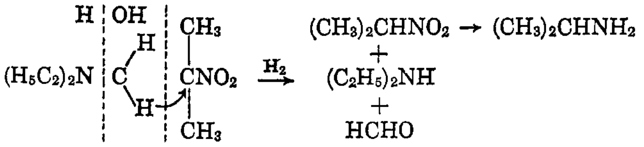
Received October 6, 1964

Hydrogenation of 1-(tertiary amino)-2-methyl-2-nitropropanes, $>NCH_2C(CH_3)_2NO_2$, was reported in good yield in cases where the tertiary amino nitrogen was in a cyclic system.[1] Under similar conditions (reduction in alcohol in the presence of Raney nickel at 30–50° and 33 atm.) 1-dimethylamino- and 1-dibutylamino-2-methyl-2-nitropropanes gave good yields of the corresponding diamines.[2] However, only a 20% yield of diamine II resulted from the attempted conversion of 1-diethylamino-2-methyl-2-nitropropane (I).[3]

A particular need in this laboratory for 1-diethylamino-2-methyl-2-propylamine (II) gave us an opportunity to evaluate the hydrogenation of I under low-pressure conditions. A number of failures resulted until it was found that I deteriorated on standing.[4] In a set of reductions over a 4-week period of a single lot of I in glacial acetic acid in the presence of rhodium-on-carbon catalyst, the amount of material corresponding to II, first obtained in 57.5% yield, decreased to 47% and then to 39%. In a second set with a fresh batch of I the yield went from 55 to 42% after 2 weeks standing and to 29% after I had been used after 4 weeks. To further complicate matters g.l.p.c. showed that the diamine obtained was a 2:1 mixture of II and its N-methyl derivative III.

A new series of experiments was inaugurated using freshly prepared I immediately after distillation. In one group, hydrogenations were run in glacial acetic acid in the presence of palladium on carbon, rhodium on carbon, and platinum oxide. The second group of reductions was run in absolute ethyl alcohol using the same catalysts as well as Raney nickel. The results, which are seen in Table I, show that many low-boiling components were obtained. It is further evident that considerable methylation took place, since in every experiment but one N′,N′-diethyl-N²-methyl-2-methylpropane-1,2-diamine (III) is noted.

Senkus has shown that, tertiary amino-2-alkyl-2-nitropropanes can be hydrolyzed by water. He has also reported that, in the hydrogenation of 1-diisopropylamino-2-methyl-2-nitropropane, diisopropylamine (reaction 2) and N-methyldiisopropylamine and isopropylamine (reaction 3) were among the products obtained.[5] Reaction 3 can be one of the pathways by which side reaction occurs in the reduction of I. It cannot, however, account for III. The following scheme could lead to III and indeed be the way to all the products found in addition to II and III. Water resulting from conversion of the nitro group causes rupture of I with the release of formaldehyde which by reductive alkylation gives the N-methylated products seen in Table I.



To determine whether II itself could lead to by-products, it was hydrogenated in the presence of rhodium catalyst in acetic acid and in the presence of Raney nickel in 95% ethyl alcohol. No uptake of hydrogen was observed nor was there any other component found by g.l.p.c.

The work was extended to cover a few other tertiary amino-2-methyl-2-nitropropanes. The 1-dimethylamino compound IV was converted to the diamine V in high yield during reduction in glacial acetic acid. The hydrogenation of IV to V could also be carried out in alcoholic solution in the presence of Raney nickel, but it was difficult to distil off solvent without loss of amine. When the corresponding 1-dibutylaminonitro compound VI was reduced, considerable cleavage occurred, giving about 25% of the diamine VII and

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[1] M. Senkus, U. S. Patent 2,426,375 (1947).

[2] H. G. Johnson, *J. Am. Chem. Soc.*, **68**, 12 (1946).

[3] G. H. Butler and F. N. McMillan, *ibid.*, **72**, 2978 (1950).

[4] Chromatography (g.l.p.c.) of I after standing several weeks showed a main peak (85%) plus 15% of a mixture of products. The vapors on opening the dark, stoppered bottle were strongly basic to test paper. Because of pressure of work in the chromatography laboratory when the material was reexamined, most of the low-boiling components had volatilized. It was possible to identify a small amount of what appeared to be N-methyldiethylamine, 0.34% of 2-nitropropane, and 0.3% of 2-methyl-2-nitro-1-propanol. The effect of air and moisture on the decomposition of I is to be studied in greater detail. Samples are to be aged in sealed moist ampoules so that low boils will not be lost and examined by g.l.p.c. after regular periods. The results will be reported at a later date.

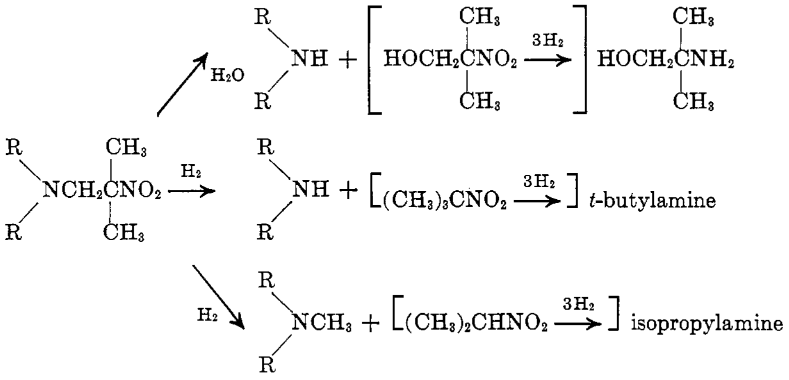
[5] M. Senkus, *J. Am. Chem. Soc.*, **72**, 2069 (1950).

TABLE I

HYDROGENATION OF I

Catalyst[a]	Solvent[b]	Time, hr.	Products of reduction,[c] %							
			G	H	J	K	L	II	III	M
A	E	3	6.6	6.4	20.6	5.5	2.3	34.6	22.7	
B	E	3	2.1	1.4	10.2	13.1		44.7	25.7	2.0
C	E	3	1.1	2.7	30.8	7.6		20.2	25.1	7.7
A	F	5	15.4		23.5	27.0		2.6	11.7	18.8[d]
A	F[e,f]	3.5	12.3	*g*	35.1			4.0	28.3	5.5
A[h]	F	8–10	18		47	35				
B	F	2–3	18.2		18.8	24.7		33.8	4.5	
B	F[e]	2	5.2	*g*	16.2	1.2		34.5	21.7	4.6
C	F	*i*								
D	F	2–3	28.5		9.5	27.6		34.3		
D	F[e]	2	6.9	3.4	23.5	12.2		49	4.3	0.5

[a] A, 5% rhodium on carbon, 15 wt. % of I; B, 5% palladium on carbon, 15 wt. % of I; C, platinum oxide, 1.5 wt % of I; D, Raney nickel, 20 wt. % of I. [b] E, glacial acetic acid; F, absolute ethyl alcohol denatured with 5 parts of methyl alcohol. [c] Determined by chromatography (g.l.p.c.) with known standards. G, isopropylamine; H, N-methylisopropylamine; J, diethylamine; K, N-methyldiethylamine; L, diisopropylamine; M, assumed to be the N-dimethyl derivative of II. [d] I. [e] Two equivalents of acetic acid was added before reduction. In the work-up before assay 2 equiv. of 50% sodium hydroxide solution was added. When more acetic acid was used, little or no change in the amount of II or III was noted. [f] When absolute alcohol containing 2 equiv. of hydrogen chloride and in later experiments absolute methyl alcohol containing 4 equiv. of acid were used, hydrogen uptake was very slow. [g] The product was present, but the amount could not be calculated because of interference by ethyl alcohol. [h] 5% rhodium on alumina was used in this run. [i] Uptake was too slow; catalyst was apparently poisoned by reduction products. When absolute alcohol containing 3 equiv. of hydrogen chloride was used, no uptake of hydrogen took place.



(1)

(2)

(3)

55% of dibutylamine. Two cyclic compounds, N-(2-methyl-2-nitropropyl)morpholine and the similar N-(nitropropyl)piperidine, were converted to the corresponding amines in good yield during hydrogenation with Raney nickel in ethyl alcohol.

From this study it would appear that in the reduction of I side reaction and resultant methylation proceeds at a much slower rate than hydrogenation leading to II. This is seen in the result of the reduction at high pressure which yielded an insignificant amount of III. If means could be found to slow down side reaction by binding the water resulting from conversion of the nitro group, it should be possible to produce II in good yield by the low-pressure reduction of I.[6] Only Raney nickel appears to have some utility. The reduction of I is further complicated by the difficulty in separating II and III during distillation. It is of interest that the bulk of the substituents on the tertiary nitrogen atom has an influence on the amount of diamine obtained in low-pressure reductions. It is also worth noting that when the tertiary nitrogen is part of a cyclic system, hydrogenation of these aminonitropropanes, as well as the N,N-dimethyl compound IV, leads to the corresponding diamines in good yield without attending methylation.

Experimental Section[7,8]

1-Diethylamino-2-methyl-2-nitropropane (I).—A mixture of 1.0 mole of 2-methyl-2-nitro-1-propanol and 2.0 moles of diethylamine was allowed to reflux gently overnight. The mixture was heated further until all the water was removed. The remaining material was collected at 90–94° (10 mm.): $n^{25}D$ 1.4392, 86% yield [lit.[3] b.p. 63–64° (2 mm.), $n^{25}D$ 1.4393].

The preparation of the other nitro compounds used in this work is described.[2,9]

Hydrogenation of I. A. In Acetic Acid.—The following reduction and subsequent work-up prior to chromatography was used with the noble metal catalysts. A solution of 35.8 g. (0.2 mole) of I[10] in 150 ml. of glacial acetic acid was hydrogenated at 25° and 3-atm. pressure in the presence of 5.0 g. of 5% rhodium on alumina.[11] Uptake was 110% of theory in 2 hr. The solution was filtered from the catalyst and concentrated under reduced pressure after the addition of 0.4 mole of concentrated hydrochloric acid. After removal of most of the acetic acid, the residue was dissolved in 50–75 ml. of water. It was kept very cold during the addition of 40–50% sodium hydroxide solution. The oily layer which separated was dried over sodium

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(6) Hydrogenation of I in glacial acetic acid containing 3–5 molar equiv. of acetic anhydride gave low-boiling materials and a low yield of acetylated II.

(7) Thanks are due to O. F. Kolsto and his associates for the microanalyses, to A. Kammer and W. Washburn for the infrared spectra, to P. F. Helgren for gas phase chromatography of some of the products of reduction, and to Mrs. Evelyn Baker and D. Nelson for the examination of I by g.l.p.c.

(8) All the tertiary amino nitro compounds were distilled just prior to reduction. Hydrogenations were not interrupted until uptake stopped.

(9) M. Senkus, U. S. Patent, 2,474,791 (1949).

(10) The material appeared to be a single component. By injecting 10-ml. samples, traces of other materials could be seen (g.l.p.c.).

(11) All the noble metal catalysts were purchased from Engelhard Industries, Newark, N. J.

hydroxide pellets. The aqueous portion was extracted once with ether, and, after drying the ether extract over sodium hydroxide pellets, it was combined with the oily layer and submitted for chromatography (see Table I).

B. **In Absolute Ethyl Alcohol.**—A solution of 17.9 g. (0.1 mole) of I in 50 ml. of absolute ethyl alcohol was reduced catalytically. After filtration from the catalyst the solution was examined (see Table I).

N′,N′-Diethyl-2-methylpropane-1,2-diamine (II).—A solution of 57.4 g. of I in 100 ml. of absolute ethyl alcohol was hydrogenated under 75-atm. pressure in the presence of 10 g. of Raney nickel. Reaction was exothermic. The temperature rose to 57° within 10 min. and uptake of hydrogen was practically complete at that time. Reaction was allowed to continue for several hours. After removal of the catalyst a sample showed the presence of 2.8% isopropylamine, 1.0% diethylamine, 2.5% N-methyldiethylamine, 90% II, and about 4% of a higher boiling component (g.l.p.c.). The remainder of the material was distilled over a long column (30 × 0.5 cm.) packed with glass helices. A constant boiling fraction, 155–156° (745 mm.), n^{25}_{D} 1.4292, was obtained, 24 g. (50% yield) shown by g.l.p.c. to be 98% II and about 2% III. The remaining material, 20–25 g., was not distilled further because of the difficulty in preventing codistillation of III.

N^1,N^1-Diethyl-N^2-methyl-2-methylpropane-1,2-diamine (III).—A series of six 0.2-mole runs of I were reduced with rhodium following the description of the hydrogenation of I in acetic acid and subsequent work-up. The combined oily residues and ether extracts were distilled over a tall packed column at atmospheric pressure until no more distillate was collected. Distillation under reduced pressure of the remainder of the material through the same column yielded a fraction, b.p. 91–96° (75 mm.), which was a 60:40 mixture of II and III; one at 90° (48 mm.); and finally the last fraction, b.p. 80° (20 mm.), n^{25}_{D} 1.4350. If it was not analyzed within minutes after distillation, it picked up carbon dioxide too rapidly to get good results.

Anal. Calcd. for $C_9H_{22}N_2$: C, 68.29; H, 14.01; N, 17.69. Found: C, 68.74; H, 14.26; N, 17.72.

Chromatography (g.l.p.c.) showed it to be completely free of II. It was used as a standard for g.l.p.c. along with II obtained from the high-pressure reduction of I until we were able to get very pure samples of II and III by means of a preparative chromatographic unit.

N,N-Dimethyl-2-methylpropane-1,2-diamine (V).—1-Dimethylamino-2-methyl-2-nitropropane (IV) was hydrogenated in acetic acid solution in the presence of rhodium on alumina. The product after work-up was obtained in quantitative yield. Chromatography indicated that it contained water. After drying over sodium hydroxide flakes and anhydrous magnesium sulfate, the filtered oily mass was refractionated: b.p. 116–119° (747 mm.), n^{25}_{D} 1.4182 [lit.[2] b.p. 119° (755 mm.), n^{20}_{D} 1.4216]. G.l.p.c. showed one component.

After hydrogenation of IV in alcohol with Raney nickel g.l.p.c. showed only one component (V) in addition to alcohol and water.

N,N-Dibutyl-2-methylpropane-1,3-diamine (VII).—The reduction of VI was carried out in acetic acid with rhodium catalyst as described for the preparation of V. Two constant-boiling fractions were obtained. The first, b.p. 80–85° (50 mm.), n^{25}_{D} 1.4160, 55% yield, was identified as dibutylamine by comparison with a known standard.[6] The second fraction, b.p. 100–114° (16 mm.), n^{25}_{D} 1.4437, 25% yield [lit.[2] 89–90° (6 mm.), n^{20}_{D} 1.4412], was confirmed as VII by analysis.

Anal. Calcd. for $C_{12}H_{28}N_2$: C, 71.93; H, 14.08; N, 13.98. Found: C, 71.92; H, 14.04; N, 14.00.

N-(2-Amino-2-methylpropyl)piperidine.—A solution of 27.6 g. (0.148 mole) of N-(2-nitro-2-methylpropyl)piperidine in 175 ml. of ethyl alcohol was hydrogenated under 2–3-atm. pressure in the presence of 3.0 g. of Raney nickel. Reaction was exothermic. Uptake of hydrogen (108%) was complete in less than 1.5 hr. A total of 0.888 mole was reduced. The combined filtrates were concentrated under reduced pressure. The resultant residue was fractionated. A total of 101.7 g. (73.4% yield) was collected at 89–89.5° (27 mm.): n^{25}_{D} 1.4565 [lit.[1] b.p. 60.5° (6 mm.)].

N-(2-Amino-2-methylpropyl)morpholine was similarly prepared. It distilled at 78–81° (6 mm.): n^{25}_{D} 1.4576, 47% yield [lit.[1] b.p. 68° (6 mm.)].

G.l.p.c. showed each product to be a single component.

The Reactions of Methyl- and *n*-Butyllithium with Dichloromethyl Methyl Ether and Dichlorodiphenoxymethane

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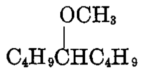
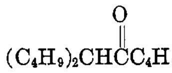
Our interest in α-alkoxycarbenes[2] prompted us to investigate the reaction of alkyllithiums with dichloromethyl methyl ether (I) in the hope of generating methoxycarbene probably as its lithium halide complex. The results we have obtained from methyllithium and I in the presence of isobutylene are in agreement with those previously published.[3]

However, when an ethereal solution of I was treated with *n*-butyllithium in hexane in the presence of added cyclohexene at −35° and allowed to react for 3 hr. at −10°, and the mixture was hydrolyzed, two major products were present as shown by v.p.c. analysis. These two components were separated by distillation through a semimicro spinning-band column. The same mixture of products was obtained in the absence of cyclohexene; therefore, the trapping of carbenoid species by cyclohexene was ruled out.

The lower boiling component was shown by its infrared, n.m.r., and mass spectra and elemental analysis to be methyl 5-nonyl ether (II), the product expected by direct substitution of the chlorines in I for *n*-butyl groups. The higher boiling component was similarly analyzed along with determining its osmometric molecular weight and shown to be 6-butyl-5-decanone (III). An authentic sample of III was prepared in very low yield by the reaction of 5-nonylmagnesium bromide[4] with *n*-valeronitrile. III failed to yield a 2,4-dinitrophenylhydrazone.[5] This lack of reactivity is typical of ketones containing more than two rather long-chain alkyl groups on the α- and α′-positions. Reduction of III with lithium aluminum hydride gave an 88% yield of an alcohol whose elemental analysis and infrared and n.m.r. spectra correspond to that of 6-butyl-5-decanol.


$$C_4H_9CH(OCH_3)C_4H_9$$

II


$$(C_4H_9)_2CHC(=O)C_4H_9$$

III

Since a ketone present in the reaction mixture would have been expected to be consumed by reaction with *n*-butyllithium, it seemed likely that III was an artifact of the reaction and its work-up. To determine the effect of hydrolysis on the reaction mixture, the reaction between *n*-butyllithium and dichloromethyl

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[1] A portion of a dissertation presented by R. A. Krueger to the Graduate School of Kansas State University, Feb. 1965, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[2] R. N. McDonald and R. A. Krueger, *Tetrahedron Letters*, **No. 14**, 857 (1965).

[3] U. Schollkopf, *Angew. Chem.*, **75**, 107 (1963); U. Schollkopf and J. Paust, *ibid.*, **75**, 670 (1963).

[4] An attempt to prepare ketone III from this Grignard reagent and *n*-valeroyl chloride failed.

[5] A synthesis of III is reported[6] along with the fact that it does not give an oxime, semicarbazone, or bisulfite derivative.

[6] D. Bardan, *Bull. soc. chim. France*, [5] **1**, 370 (1934).