

N,N-Di-2-chloroethyl-*t*-octylamine Hydrochloride.—Thionyl chloride (59.5 g., 0.5 mole) was slowly added to 2,2'-(*t*-octylimino)-diethanol (51.2 g., 0.25 mole) and benzene (40 ml.) at 40°. After the vigorous reaction had subsided, additional thionyl chloride (119 g.) was added rapidly. The mixture was allowed to stand overnight. After evaporation of excess thionyl chloride and solvent, the solid residue was recrystallized from ethanol containing a little acetone. The white powder weighed 54.7 g. (74%), m.p. 135° (with decomposition).

Anal. Calcd. for C₁₂H₂₆Cl₂N: N, 4.82; Cl, 36.6. Found: N, 4.81; Cl, 35.9.

N-2-Chloroethyl-*t*-octylamine hydrochloride, m.p. 188–189°, was prepared similarly in 76% yield from 2-*t*-octylaminoethanol.

Anal. Calcd. for C₁₀H₂₃Cl₂N: N, 6.14; Cl, 31.1. Found: N, 6.37; Cl, 31.5.

N-*t*-Octylethyleneimine.—Gaseous hydrogen chloride was bubbled into 2-(*t*-octylamino)-ethanol (173 g., 1 mole) dis-

solved in ether-petroleum ether. The solid hydrochloride, which was collected and dried in air, was added in portions to chlorosulfonic acid (127 g., 1.1 moles). The mixture was heated on a steam-bath for 4 hr., then evaporated under reduced pressure. The residue was slurried with water (500 ml.) and treated with a solution of potassium hydroxide (300 g.) in water (400 ml.). The mixture was steam distilled and the product separated as an oil from the distillate. The aqueous layer was extracted with chloroform and the combined organic layers were dried over anhydrous magnesium sulfate. Upon distillation, the product (64 g., 41%) was obtained as a colorless oil, b.p. 94–98° (25 mm.).

Anal. Calcd. for C₁₀H₂₁N: N, 9.0. Found: N, 8.7.

1-*t*-Octyl-2-methylethyleneimine was prepared similarly in 76% yield from 1-*t*-octylamino-2-propanol, b.p. 113–116° (25 mm.), *n*_D²⁵ 1.4334, *d*₄²⁵ 0.8057.

Anal. Calcd. for C₁₁H₂₃N: N, 8.3. Found: N, 8.4.

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[CONTRIBUTION FROM THE ROHM & HAAS COMPANY]

t-Carbinamines, RR'R''CNH₂. II. Cyanoalkylations and Related Reactions¹

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Cyanomethylation of primary *t*-carbinamines did not differ from the reaction of primary aliphatic amines in general. The degree of substitution of the product depended primarily on the molar proportion of the reagents. Cyanomethylation of derivatives of *t*-carbinamines, as well as the reaction of the amines with higher aldehydes and hydrogen cyanide, also proceeded normally, but their reactions with ketone cyanohydrins failed. By contrast, the addition of *t*-carbinamines to ethyl acrylate and especially to acrylonitrile or to methyl methacrylate showed definite steric influences. Reactions of the amines with acrylonitrile and with methyl methacrylate were greatly accelerated by operation under acidic conditions.

A study of the preparation of aminonitriles and related compounds has afforded an opportunity for the comparison of the behavior of highly branched primary amines and their derivatives² with other amines.

A large number of α -aminonitriles were prepared from *t*-butylamine (I), *t*-octylamine (II, 1,1,3,3-tetramethylbutylamine) and their secondary amine derivatives. Particular attention was given to the synthesis of glycinonitriles which can be prepared conveniently from commercially available glycolonitrile³ or from hydrogen cyanide and aqueous formaldehyde solution.

The principal factor which determined the degree of substitution in the cyanomethylation of primary amines was the molar proportions of the reagents. Thus, excellent yields of *monocyanomethylated* amines were obtained by the use of equimolar proportions. Other reaction variables had little effect. These included the nature of the cyanomethylation reagent (glycolonitrile or hydrogen cyanide and formaldehyde added separately), dilution with organic solvents or water, temperature range (30 to 80°) and duration of reaction period.

Dicyanomethylated derivatives of I or II were prepared in excellent yields by charging two molar equivalents of the cyanomethylation reagent per

mole of amine. The reactions were accelerated by the addition of small amounts (5 to 10 mole per cent.) of acidic materials, such as mineral acids or acid salts, and by operation at somewhat elevated temperature.

Other, less-branched amines of similar molecular weight gave either mono- or dicyanomethylated derivatives under the same conditions and in comparable yields. The desired product was again obtained in each instance by control of the charge. The yields were not affected by chain length. The properties of these compounds, of which most are new, are listed in Tables I and II.

The results indicate that steric considerations are unimportant in the cyanomethylation of primary amines. The exclusive and facile formation of monocyanomethylated product when desired is a consequence of the large difference between the basic strengths of aliphatic amines and α -aminonitriles. Because of their low basicity,⁴ the latter cannot compete with primary amines in their reaction with cyanohydrins.

A variety of derivatives of I and II were cyanomethylated similarly in satisfactory yields (Table III). The lone failure occurred in the attempted cyanomethylation of N-*t*-octyl-2-ethylhexylamine. This result may indicate steric influence, since the isomeric di-*n*-octylamine was successfully converted to the expected nitrile. However, the possibility of decomposition during distillation, which was noted to some extent in other instances, cannot be ruled out.

(1) Presented in part before the Division of Organic Chemistry at the 119th Meeting of the American Chemical Society, Cleveland, Ohio, April 10, 1951.

(2) N. Bortnick, L. S. Luskin, M. D. Hurwitz, W E Craig, L. J. Exner and J. Mirza, *THIS JOURNAL*, **78**, 4039 (1956); also forthcoming papers in preparation.

(3) L. J. Exner, L. S. Luskin and P. L. de Benneville, *ibid.*, **75**, 4841 (1953), lists pertinent references.

(4) A. Marxer, *Helv. Chim. Acta*, **37**, 166 (1954).

TABLE I
 MONOCYANOMETHYLAMINES, RNHCH₂CN

No.	R	Yield, %	°C.	B.p.	Mm.	<i>n</i> _D ²⁰	<i>d</i> ₄ ²⁵	Nitrogen, %	
								Calcd.	Found
III	<i>n</i> -C ₄ H ₉ -	86	65-66		2.5	1.4326	...	25.0	24.6
IV ^a	(CH ₃) ₃ C-	89	58-60		3	1.4295	0.8756	25.0	24.9
V	(CH ₃) ₃ CCH ₂ C(CH ₃) ₂ - ^b	83	91-96		3.5	1.4492	8808	16.7	16.7

^a H. J. Backer and H. Mulder, *Rec. trav. chim.*, **52**, 454 (1933), reported b.p. 83-88° (14 mm.). ^b Reference 3 reported yields of 66 and 75% in the preparation of *n*-octyl- and 2-ethylhexylglycinonitriles, respectively. These yields are probably not maximum.

 TABLE II
 DICYANOMETHYLAMINES RN(CH₂CN)₂

No.	R	Yield, %	°C.	B.p.	Mm.	<i>n</i> _D ²⁰	<i>d</i> ₄ ²⁵	Nitrogen, %	
								Calcd.	Found
VI	(CH ₃) ₃ C-	55	88		0.4		M.p. 38-39	27.8	27.6
VII	<i>n</i> -C ₈ H ₁₇ -	85	173-177		3.5	1.4506	0.9209	20.3	19.4
VIII	<i>n</i> -C ₈ H ₁₁ CH(CH ₃)-	85	165-172		3	1.4526	.9305	20.3	20.2
IX	(CH ₃) ₃ CCH ₂ C(CH ₃) ₂ -	88	135-137		0.8	1.4664	.9554	20.3	20.2

 TABLE III
 CYANOMETHYLATED SECONDARY AMINES R(R')NCH₂CN

No.	R	R'	Yield, %	°C.	B.p.	Mm.	<i>n</i> _D ²⁰	<i>d</i> ₄ ²⁵	Nitrogen, %	
									Calcd.	Found
XV	(CH ₃) ₃ C-	NCCH ₂ CH ₂ -	78	146-154		1.5	1.4600	0.9721 ^b	25.4	25.3
XVI	(CH ₃) ₃ C-	C ₂ H ₅ OOCCH ₂ CH ₂ -	53	144-145		13	1.4477	.9891 ^b	13.2	13.2
XVII ^a	<i>n</i> -C ₈ H ₁₇ -	<i>n</i> -C ₈ H ₁₇ -	50	180-200		6	1.4298	.8493	10.0	10.0
XVIII	(CH ₃) ₃ CCH ₂ C(CH ₃) ₂ -	CH ₃ -	60	100-120		6	1.4503	.8820	16.5	15.9
XIX	(CH ₃) ₃ CCH ₂ C(CH ₃) ₂ -	C ₂ H ₅ CH ₂ -	52	142-150		15	1.5078	.9546	10.8	10.3
XX	(CH ₃) ₃ CCH ₂ C(CH ₃) ₂ -	CH ₂ CH ₂ CH ₂ CHCH ₂- <u> | </u> <u> O </u>	49	139-143		0.3	1.4700 ^b	...	11.1	10.5
XXI	(CH ₃) ₃ CCH ₂ C(CH ₃) ₂ -	HOCH ₂ CH ₂ -	86	.....^c		..	.....	.....	13.2	12.8 ^c
XXII	(CH ₃) ₃ CCH ₂ C(CH ₃) ₂ -	NCCH ₂ CH ₂ -	81	.....		..	M.p. 49-50.5		19.0	18.8
XXIII	(CH ₃) ₃ CCH ₂ C(CH ₃) ₂ -	C ₂ H ₅ OOCCH ₂ CH ₂ -	74	144-155		2	1.4594 ^b	0.9472	10.4	10.4

^a D. B. Luten, *J. Org. Chem.*, **3**, 590 (1939), reported b.p. 145-150° (3 mm.) for the product (31% yield) by the method of E. Immendorfer, *Ber.*, **48**, 606 (1915). ^b At 20°. ^c Decomposed in attempted distillation; yield and analysis for undistilled concentrate.

The reactions of I or II with higher aldehydes and hydrogen cyanide gave the expected α -aminonitriles in moderate yields.

The *t*-carbinamines failed to react with acetone cyanohydrin. The expected product would contain two *t*-carbinyl groupings linked to the nitrogen atom. Molecules of this type are unstable and their synthesis is known to be difficult.

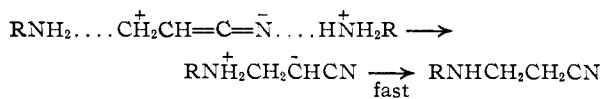
Steric effects are particularly important in the preparation of β -aminonitriles from amines and acrylonitrile. This reaction is definitely influenced both by size and by branching of the alkyl groups.⁵ A substantial reduction in yield has been reported in the cyanoethylation of *t*-butylamine (56%) as compared to the other butylamines (83-98%).⁶

t-Octylamine was even more resistant to the action of acrylonitrile. The use of elevated temperature, extended reaction periods or basic catalysts failed to provide yields above 30%. The unlikelihood of a molecular weight effect was indicated by an excellent yield of product obtained by a normal treatment of 2-ethylhexylamine.

When acidic reaction conditions were used, how-

ever, the desired products were prepared from I or II in high yield. Effective catalysis was afforded by operation in dilute aqueous acetic acid or by the addition of small amounts of concentrated hydrochloric acid to the reagents without additional solvent.

Cyanoethylation in acidic media has been reported only for certain aromatic amines. It is suggested that these reactions may be an illustration of addition reactions which proceed by way of concerted processes⁷



A small amount of *N-t*-butyliminodipropionitrile was also isolated from the acid-catalyzed reaction of I with acrylonitrile. Attempts to prepare the corresponding derivative of II were unsuccessful.

Aminopropionates and iminodipropionates have been obtained by the addition of amines to acrylic esters.⁸ From the meager data available, the nature of the principal product would seem to be governed by the molar proportion of the reagents.

The products obtained from the reaction of approximately equimolar amounts of I or II with

(7) T. M. Lowry and I. J. Faulkner, *J. Chem. Soc.*, **127**, 2883 (1925); C. G. Swain, *THIS JOURNAL*, **72**, 4578 (1950).

(5) (a) H. Bruson, "Organic Reactions," Vol. V, John Wiley and Sons, Inc., New York, N. Y., 1949, p. 84; (b) J. H. Burckhalter, E. M. Jones, W. F. Holcomb and L. A. Sweet, *THIS JOURNAL*, **65**, 2012 (1943); (c) F. C. Whitmore, H. S. Mosher, R. R. Adams, R. B. Taylor, E. C. Chapin, C. Weisel and W. Yanko, *ibid.*, **66**, 725 (1944); (d) G. B. Bachman and R. L. Mayhew, *J. Org. Chem.*, **10**, 243 (1945).

(6) D. S. Tarbell, N. Shakespeare, C. J. Claus and J. F. Bunnett, *THIS JOURNAL*, **68**, 1217 (1946); D. S. Tarbell and D. K. Fukushima, *ibid.*, **68**, 2499 (1946).

(8) E. H. Riddle, "Monomeric Acrylic Esters," Reinhold Publishing Corp., New York, N. Y., 1954, p. 158.

acrylates were principally monoesteramines. A small amount of diesteramine was also obtained from I.

The reaction of aliphatic primary amines above ethylamine with methacrylic esters, hitherto unreported, showed important steric influence. Thus, the yields obtained in the addition of *n*-butylamine,⁹ I and II to methyl methacrylate were 58, 26 and 14%, respectively.

The catalytic effect of an acidic medium was again noted.¹⁰ The addition of small amounts of hydrochloric acid to the reaction mixture increased the yields obtained from I and II to 42 and 33%, respectively. No attempt was made to determine the optimum acid concentration.

Experimental¹¹

***N*-*t*-Octylglycinonitrile (V).** A. — A solution of II (129 g.) in 50% aqueous ethanol (110 g.) was stirred and heated under reflux while 50% aqueous glycolonitrile (114 g.) was added dropwise during 1 hour. Stirring and heating was continued for 5 hr. Magnesium sulfate (50 g.) was added to assist the separation of layers. The upper oil layer was distilled to give 140 g. (83%) of a colorless liquid, b.p. 91–96° (3.5 mm.).

n-Butylglycinonitrile (III) and *t*-butylglycinonitrile (IV) were prepared similarly (Table I).

B. — After the successive additions of 37% formalin (584 g.) and hydrogen cyanide (189 g.) to II (903 g.) at room temperature, the mixture was allowed to stand overnight. The crude oil layer, after drying under reduced pressure, weighed 1115 g. (95%). Distillation of a 200-g. portion gave 168 g. (80%) of product, b.p. 108–112° (6 mm.).

***N*-*t*-Octyliminodiacetonitrile (IX).** — A mixture of II (1806 g.), sodium bisulfate (84 g.) and water (150 g.) was stirred at 15–20° while 36% formalin (2334 g.) and hydrogen cyanide (782 g.) were added in succession. Stirring was continued for 2 hr. at 20–25° and 1.5 hr. at 50°. The oil layer was removed and distilled through a short column packed with glass helices to give 2554 g. (88%) of a colorless oil, b.p. 135–137° (0.8 mm.).

t-Butyliminodiacetonitrile (VI), *n*-octyliminodiacetonitrile (VII) and 2-octyliminodiacetonitrile (VIII) were obtained similarly. However, concentrated hydrochloric acid (10 g. per mole) was substituted for the sodium bisulfate solution (Table II).

α -*N*-*t*-Butylaminoisovaleronitrile (X). — Isobutyraldehyde (144 g.) was added to a solution of hydrogen cyanide (81 g.) and piperidine (5 ml.) in anhydrous ether (200 ml.) below 25°. After 3 hr., compound I (146 g.) was added, keeping the temperature below 30°. Stirring was continued for 2 hr. Benzene was added to assist in the separation of water. The benzene layer was then distilled to give 145 g. (47%) of a colorless oil, b.p. 70–72° (5 mm.), n_{25}^D 1.4305.

Anal. Calcd. for $C_9H_{18}N_2$: N, 18.2. Found: N, 17.7.

α -*N*-*t*-Octylaminoisovaleronitrile (XI). — A mixture of isobutyraldehyde cyanohydrin¹² (24.8 g.) and II (32.3 g.) was stirred at 55 to 60° for 9 hr. Benzene was added and the water layer was removed. The pale yellow oil remaining after evaporation of solvent was washed with dilute aqueous solutions of sulfuric acid and sodium carbonate and finally with water. After drying, the oil weighed 37.5 g. (52%), n_{25}^D 1.4476, d_{25}^{25} 0.8711. The oil could not be distilled without extensive decomposition.

Anal. Calcd. for $C_{13}H_{26}N_2$: N, 13.3. Found: N, 13.2.

β -*N*-*t*-Octylaminopropionitrile (XII). — II (325 g.) and acrylonitrile (199 g.) were added rapidly to a solution of acetic acid (62.5 g.) in water (250 ml.). The whole was

(9) The reaction of *n*-butylamine with methyl methacrylate was carried out by N. Bortnick and P. J. McNulty, Jr.

(10) P. Bieber, *Ann. chim.*, [12] 9, 685 (1954), has reported the catalytic effect of acetic acid as a medium for the reaction of aniline with methyl methacrylate.

(11) Some of the experimental work was done by Thomas Walton, Jr., A. J. McFaul and Rita Cerruti.

(12) A. J. Ultee, *Rec. trav. chim.*, 28, 248 (1909).

stirred and heated under reflux for 20 hr. After cooling, the mixture was neutralized with sodium bicarbonate. The oil layer was removed and combined with benzene extracts of the aqueous layer. Distillation gave 378 g. (83%) of a colorless oil, b.p. 100–105° (1.5–2 mm.), n_{20}^D 1.4509, d_{20}^{20} 0.8743.

Anal. Calcd. for $C_{11}H_{22}N_2$: N, 15.4. Found: N, 15.1.

β , β -*N*-*t*-Butyliminodipropionitrile (XIV) was obtained as the higher-boiling fraction of a similar treatment of I in 8% yield, b.p. 121–130° (0.4 mm.), n_{25}^D 1.4630, d_{25}^{25} 0.9673.

Anal. Calcd. for $C_{10}H_{17}N_3$: N, 23.5; neut. equiv., 179. Found: N, 23.5; neut. equiv. (HClO₄ in acetic acid), 179.

The yield of *t*-butylaminopropionitrile (XIII), b.p. 69–71° (1.5 mm.), n_{20}^D 1.4316, was 78%.

***N*- β -Cyanoethyl-*N*-*t*-octylglycinonitrile (XXII).** — A solution of *t*-octylaminopropionitrile (683 g.) in 95% ethanol (1020 g.) was cooled and stirred at 15° while 36.5% formalin (30.8 g.) and hydrogen cyanide (101 g.) were added in succession, each in 30 minutes. After being stirred overnight at 20–25°, the mixture was warmed at 50° for 2 hr. The dark oil (710 g.) which remained after evaporation of low-boiling materials crystallized on cooling in ice. It was dissolved in 400 ml. of petroleum ether (60–80°); the solution was decanted from undissolved tarry materials and boiled with decolorizing carbon. The clear red filtrate deposited light tan crystals which were collected and washed with cold petroleum ether. The solid weighed 676 g. (82%), m.p. 49–50.5°.

Compounds XV to XX and XXIII were obtained similarly and were purified by distillation of the residual oil. *N*- β -Hydroxyethyl-*N*-*t*-octylglycinonitrile (XXI) could not be distilled without extensive decomposition (Table III).

Ethyl β -*N*-*t*-butylaminopropionate (XXIV) was prepared by the procedure of Ziering, Berger, Heinemann and Lee¹³ from I (36.5 g.), ethyl acrylate (150 g.) and absolute alcohol (75 ml.) in 90% yield, b.p. 90–92° (20 mm.), n_{20}^D 1.4262.

Anal. Calcd. for $C_8H_{15}NO_2$: N, 8.0. Found: N, 8.0.

There was also 2 g. of a higher-boiling fraction, b.p. 146° (6 mm.), n_{20}^D 1.4447, which was probably diethyl β , β -*N*-*t*-butyliminodipropionate (XXV).

Anal. Calcd. for $C_{12}H_{27}NO_4$: N, 4.8. Found: N, 4.8.

Ethyl β -*N*-*t*-Octylaminopropionate (XXVI). — A mixture of II (607 g.), ethyl acrylate (470 g.) and *t*-butyl alcohol (1930 ml.) was heated under reflux for 8 hr. Distillation gave 930 g. (86%) of the colorless product, b.p. 101–103° (3 mm.), n_{25}^D 1.4423, d_{25}^{25} 0.9065.

Anal. Calcd. for $C_{13}H_{27}NO_2$: N, 6.1. Found: N, 6.1.

Methyl β -*N*-*t*-Butylamino- α -methylpropionate (XXVII). — A solution of I (36.5 g.) in methyl methacrylate (50 g.) was heated under reflux for 48 hr. The temperature gradually rose from 62 to 72°. Distillation gave 23 g. (26%) of the colorless product, b.p. 49–50° (1 mm.), n_{25}^D 1.4232, d_{25}^{25} 0.9051.

Anal. Calcd. for $C_9H_{19}NO_2$: N, 8.0; neut. equiv. 173.2. Found: N, 8.0; neut. equiv. (HClO₄ in acetic acid), 173.5.

When concentrated hydrochloric acid (1 ml.) was added to the above reaction mixture, the temperature after 48 hr. of heating was 80°. Distillation gave 36.5 g. (42%) of product, n_{25}^D 1.4231.

Methyl β -*N*-*t*-octylamino- α -methylpropionate (XXVIII) was obtained similarly; the temperature was held at 90–95° for 48 hr. From 65 g. of I, there was obtained 16.5 g. (14%) and 36.5 g. (33%) of the product from the uncatalyzed and acidified runs, respectively; n_{25}^D 1.4407, d_{25}^{25} 0.9052, b.p. 75° (0.5 mm.).

Anal. Calcd. for $C_{13}H_{27}NO_2$: N, 6.1; neut. equiv., 229.4. Found: N, 6.0; neut. equiv., 229.5.

Methyl β -*N*-*n*-butylamino- α -methylpropionate (XXIX) was prepared similarly by heating *n*-butylamine (365 g.) and methyl methacrylate (500 g.) under reflux for 6 hr. Distillation gave 509 g. (58%) of the product, b.p. 58–60° (1 mm.), n_{25}^D 1.4279, d_{25}^{25} 0.9105.

Anal. Calcd. for $C_9H_{19}NO_2$: N, 8.0. Found: N, 8.0.

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(13) A. Ziering, L. Berger, S. D. Heinemann and J. Lee, *J. Org. Chem.*, 12, 901 (1947).