malonate). An analytical sample prepared by recrystallization from ethanol had m.p. 154–155° and a broad infrared absorption peak at 5.60–5.81 μ.

Anal. Calcd. for $C_{24}H_{22}N_2O_7$: C, 64.00; H, 4.88; N, 6.22. Found: C, 64.41; H, 5.16; N, 5.96.

1-*p*-Tolyl-3-chloro-4,4-dicarbethoxy-azetidin-2-one (XXIII).—A benzene solution of 5.3 g. of diethyl *p*-toluidinomalonate and 3.5 g. of dichloroacetyl chloride was heated under reflux for 3.5 hours. On working up the reaction mixture in the usual manner, 6.45 g. (86.5%) of a yellow, viscous oil was obtained which had peaks at 5.65–5.75 and 5.9 but no absorption at the 3 μ region.

When triethylamine was added to a benzene solution of the above intermediate there was no immediate reaction. After a few days a small quantity of crystals appeared. At the end of several weeks 0.9 g. of crystalline solid was removed by filtration and the filtrate was washed with dilute acid and with water, dried and evaporated. The product (1.46 g., 62%) was a yellow, viscous oil, $n^{25}D$ 1.5277, which showed strong absorption at 5.60 (β-lactam carbonyl) and 5.73 μ (ester carbonyl). Since this compound could not be induced to crystallize, purification was attempted through distillation (110° (0.05 mm.)). The distillate was a light yellow, viscous oil with the following analysis.

Anal. Calcd. for $C_{18}H_{18}ClNO_6$: C, 56.56; H, 5.34; N, 4.12. Found: C, 57.33; H, 5.99; N, 4.25.

No precipitate was formed when this compound was boiled with alcoholic silver nitrate for 15 minutes.

Hydrogenation of 1-(*p*-Tolyl)-3-chloro-4,4-dicarbethoxy-azetidin-2-one.—A solution of 0.5 g. of the halo-β-lactam in ethyl acetate was hydrogenated in presence of 0.3 g. of 10% Pd-on-charcoal and 0.3 g. of magnesium oxide. When the hydrogen uptake stopped, the reaction mixture was filtered and the filtrate evaporated to afford 0.3 g. of crystalline material of m.p. 85–87°. On recrystallization from cyclohexane, the m.p. rose to 89.5–90.5°. It was identified as 1-*p*-tolyl-4,4-dicarbethoxy-azetidin-2-one (XXV) from its m.p., infrared spectrum and m.m.p. with an authentic sample of this β-lactam.

Diethyl dibromoacetanilidomalonate, m.p. 84–85°, λ_{max} 5.75 and 6.0 μ, was prepared in 79% yield by refluxing for 4 hours a benzene solution of diethyl anilinomalonate, dibromoacetic acid and phosphorus trichloride.

Anal. Calcd. for $C_{15}H_{17}Br_2NO_5$: C, 39.91; H, 3.77; N, 3.10. Found: C, 40.31; H, 4.01; N, 3.25.

1-Phenyl-3-bromo-4,4-dicarbethoxy-azetidin-2-one (XXII).—When triethylamine was added to a benzene solution of the above intermediate, an immediate reaction ensued and crystalline triethylamine hydrobromide started to separate. After storing overnight at room temperature the crystals (2.4 g., 98%) were removed by filtration and the filtrate worked up in the usual manner to give a viscous liquid which on evaporative distillation afforded a light yellow colored liquid, $n^{26}D$ 1.5215, λ_{max} 5.68 and 5.74 μ. The liquid could not be obtained analytically pure. However, on catalytic hydrogenation it absorbed nearly one mole of hydrogen and gave the known 1-phenyl-4,4-dicarbethoxy-azetidin-2-one (XXIV) in a nearly quantitative yield.

KHARAGPUR, INDIA

[CONTRIBUTION FROM THE ORGANIC CHEMISTRY DEPARTMENT, RESEARCH DIVISION, ABBOTT LABORATORIES]

A Low Pressure Process for the Reduction of Nitriles. Use of Rhodium Catalyst[1]

BY MORRIS FREIFELDER

RECEIVED JULY 9, 1959

A low pressure catalytic reduction procedure for the conversion of sixteen aliphatic nitriles to primary amines is described. The hydrogenations are carried out at room temperature in the presence of ammonia in a Parr apparatus, using 5% rhodium-on-alumina. No hydrogenolysis of the benzyl grouping was observed using this catalyst. Of particular interest is the reduction of 3-indoleacetonitrile to tryptamine under low pressure conditions. Except for 3-indoleacetonitrile the nitrile used in this study are of the type $R(CH_2)_nCN$ wherein R is a substituted nitrogen atom or an ether moiety.

Catalytic hydrogenation of basic nitriles has generally been carried out with nickel using the procedure of Whitmore.[2]

We now find that with rhodium catalyst such drastic conditions are not necessary. As an example of the Whitmore method, in the reduction of 3-indoleacetonitrile Thesing and Schülde[3] used at least an equal weight of Raney nickel catalyst and hydrogen pressure of 90 atmospheres in the presence of ammonia to obtain a good yield of tryptamine.[4a,b,c]

In contrast with these described procedures, low pressure hydrogenation of 3-indoleacetonitrile using a 10–20% ratio of 5% rhodium-on-alumina, in the presence of ammonia, was complete in a short time and a good yield of tryptamine was obtained. However, reduction in the absence of ammonia gave predominantly secondary amine contaminated with some tryptamine. The use of strong base in the absence of ammonia[5a,b] also gave the same result.

The procedure of using rhodium catalyst in the reduction of nitriles has several advantages. There are reports of Raney nickel reduction of basically substituted nitriles under moderate conditions.[6a,b] However, the ease with which they are reduced with rhodium at room temperature and 2–3 atmospheres (in less than two hours) makes this method appear to be the one of choice. In general, yields, as shown in Table I, are good. The method gave good results when applied to the reduction of β-cyanoethyl ethers and should supplant the pro-

(1) Presented at the 136th Meeting of the American Chemical Society, Atlantic City, N. J., September 14, 1959.

(2) F. C. Whitmore, *et al.*, THIS JOURNAL, **66**, 725 (1944). The method comprises hydrogenation of nitriles with Raney nickel and ammonia at 90–130° and 70–270 atmospheres pressure.

(3) J. Thesing and F. Schülde, *Ber.*, **85**, 324 (1952).

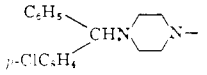
(4) (a) Protiva, *et al.*, *Collection Czech. Chem. Comms.*, **24**, 74 (1959), commented on the large amount of catalyst necessary to achieve a fair yield of tryptamine by this method; (b) W. Schindler, *Helv. Chim. Acta*, **40**, 2156 (1957), prepared isotryptamine from 2-indoleacetonitrile in a similar manner; (c) in this Laboratory erratic results were obtained following the Thesing and Schülde procedure. In some instances as much as 28 hours was required to complete uptake of hydrogen. Hydrogenation was satisfactory only when 200 to 300% by weight of Raney nickel was used.

(5) (a) M. Fluchaire and F. Chambret, *Bull. soc. chim. France*, **11**, 22 (1944); (b) M. Grunfeld, U. S. Patent 2,449,036.

(6) (a) Good yields of some dialkylaminopropylamines are reported by J. H. Burckhalter, E. M. Jones, W. F. Holcomb and L. A. Sweet, THIS JOURNAL, **65**, 2012 (1943), from reduction of the corresponding nitriles with Raney nickel and ammonia at 70° and 4 atmospheres; (b) W. Huber, *ibid.*, **66**, 876 (1944), reduced some basically substituted nitriles in a similar manner at 12 atmospheres in a specially prepared piece of apparatus.

TABLE I

N'-SUBSTITUTED ALKYLENEDIAMINES, $R(CH_2)_nNH_2$

Compound	R	n	Yield, %	B.p. °C.	B.p. Mm.	n_D	t, °C.	Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Nitrogen, % Calcd.	Nitrogen, % Found
I	$(H_3C)_2N-$	2	68.4[a]	103–108	755	1.4238	25	$C_4H_{12}N_2$						
II	1-Piperidino	2	78[b]	60	7			$C_7H_{16}N_2$						
III	4-Methyl-1-piperazino	2	92.5	87–90	11–13	1.4789	23	$C_7H_{17}N_3$	58.70	58.64	11.97	12.03	29.33	29.68
				207–212	753									
IV	$C_6H_5CH_2N(CH_3)$	2	67.2	96–100	1.9	1.5140	26	$C_{10}H_{16}N_2$	73.12	73.34	9.82	9.86	17.06	17.05
V		2	81.7[c]	210–214	1.2	1.5813	26	$C_{19}H_{24}ClN_3$	69.17	69.17	7.33	7.58	12.73	12.86
VI	$C_6H_5CH_2N(CH_3)-$	3	63[d]	128–130	10	1.5177	25.5	$C_{11}H_{18}N_2$	74.11	74.04	10.18	10.00	15.71	15.77
VII	4-Methyl-1-piperazino	3	67.8[e]	113–114	17	1.4788	24	$C_8H_{19}N_3$						
VIII	$(H_3C)_2N-$	4	69[f]	64				$C_6H_{16}N_2$	62.01	62.07	13.88	14.04	24.11	23.89
IX	$(H_3C)_2N-$	5	68.4[g]	179[h]	753	1.4402	25	$C_7H_{18}N_2$						

[a] Hydrogenation of the nitrile carried out with ammonia but no solvent at 70 atmospheres. Without ammonia yield dropped to 43%. In addition, 20% of secondary amine, b.p. 195–197°, was obtained. Physical constants of compound I and secondary amine compare with those described in ref. 10. [b] Identified as the picrate, m.p. 225° dec., as reported by W. O. Kermack and J. F. Smith, *J. Chem. Soc.*, 3096 (1931). [c] The dihydrochloride salt was prepared. *Anal.* Calcd. for $C_{19}H_{24}ClN_3 \cdot 2HCl$: N, 9.97; ionic Cl, 17.13. Found: N, 10.4; ionic Cl, 17.50. [d] Loss appears to be mechanical. In a large size run at 60 atmospheres, the yield was 75%. In each case, however, the forerun and residue after distillation amounted to about 5% of the weight of residue before distillation. [e] L. M. Rice and C. H. Grogan, *J. Org. Chem.*, **20,** 1687 (1955), prepared this amine in 40% yield by reduction of the nitrile with lithium aluminum hydride. Their product boiled at 52° (0.3 mm.). [f] W. Huber, R. O. Clinton, W. Boehme and M. Jackman, THIS JOURNAL, **67,** 1618 (1945), obtained 58% yield, b.p. 74–75° (45 mm.), following the method of Huber; see ref. 6b. [g] Yield dropped to 43% when amount of ammonia was decreased to 3 molar equivalents. [h] Described b.p. 184–185° (768 mm.); see J. von Braun, *Ann.*, **382,** 1 (1944).

TABLE II

γ-AMINOPROPYL ETHERS, $ROCH_2CH_2CH_2NH_2$

Compound	R	Yield, %	B.p. °C.	B.p. Mm.	Ref. index	t, °C.	Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Nitrogen, % Calcd.	Nitrogen, % Found
X	H_3C-[a]	72	114[b]	752	1.4163	24	$C_4H_{11}NO$						
XI	$C_6H_{13}-$	90.5	85–86	7	1.4340	23.5	$C_9H_{21}NO$[c]	67.86	68.2	13.29	13.43	8.79	9.09
XII	Cyclopentyl	69	60	3	1.4561	24	$C_8H_{17}NO$	67.09	67.14	11.96	12.21	9.79	9.83
XIII	Hexahydrobenzyl	70	86–90	2	1.4610	27	$C_{10}H_{21}NO$	70.12	69.85	12.35	12.52	8.18	8.25
XIV	Cycloheptyl	75 8	96–100	2.5	1.4690	26	$C_{10}H_{21}NO$	70.12	70.30	12.35	12.70	8.18	8.06

[a] Hydrogenation of β-cyanoethyl methyl ether carried out without solvent at room temperature and 70 atmospheres with 5 equivalents of ammonia. In a low pressure hydrogenation in methanol in the absence of ammonia about 5% of X was obtained. [b] Described b.p. 117–118°; see ref. 7. [c] Calcd.: O, 10.06. Found: O, 10.25.

TABLE III

SECONDARY AMINES, $R(CH_2)_n]_2NH$

Compound	R	n	Yield, %	B.p. °C.	B.p. Mm	n_D	t, °C.	Formula	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found	Nitrogen, % Calcd.	Nitrogen, % Found
XV	Cyclopentyloxy-	3	9.6	150–153	2	1.4690	24	$C_{16}H_{31}NO_2$	71.34	71.50	11.60	11.55	5.20	5.37
XVI	Hexahydrobenzyloxy-	3	11.3	190	1.9	1.4717	27	$C_{20}H_{39}NO_2$	73.79	73.80	12.08	12.04	4.30	4.46
XVII	Cycloheptyloxy-	3	10.0	198–201	1.6	1.4808	26	$C_{20}H_{39}NO_2$	73.79	73.31	12.08	12.16		
XVIII	$(H_3C)_2N-$	4	8.6	106	1.4			$C_{12}H_{29}N_3$	66.91	67.04	13.57	13.55	19.51	19.41
XIX	$(H_3C)_2N-$	5	20[a]	132–135	2.0	1.4540	25	$C_{14}H_{32}N_2$	69.07	69.61	13.66	13.49		

[a] Secondary amine obtained in the reduction of 4-dimethylaminovaleronitrile when 3 equivalents of ammonia were used; see ref. *f*, Table I.

cedure used by Utermohlen.[7] The γ-aminopropyl ethers obtained by this method are shown in Table II.

Another advantage appears to lie in the selectivity of rhodium, which despite its high catalytic activity and its relationship to palladium, did not appear to cause any hydrogenolysis[8] in the preparation of compounds IV and VI listed in Table I.

The ability of this versatile catalyst to increase the rate of hydrogenation over hydrogenolysis in the reduction of certain α-aminonitriles[9a,b] adds to its usefulness.

Piperidinoacetonitrile and 4-methylpiperazinoacetonitrile are converted to the corresponding β-aminoethyl derivatives (compounds II and III, Table I) in high yield with rhodium. β-Dimethylaminoethylamine I is obtained in 68% yield from dimethylaminoacetonitrile.[10] This particular reduction was run at higher pressure (70 atmospheres) in the absence of solvent for expediency. In the absence of solvent hydrogenation at low pressure is extremely slow. Reduction at low pressure can be achieved when a solvent is used. However the extreme volatility of the base makes removal of the solvent difficult without losing amine. Higher pressure reduction was used in the prepa-

(7) W. P. Utermohlen, Jr., THIS JOURNAL, **67,** 1505 (1945), hydrogenated a number of alkoxypropionitriles under 100 atmospheres pressure using essentially the method of Whitmore described in ref. 2.

(8) W. H. Hartung and R. Simonoff, "Organic Reactions," Vol. VIII, John Wiley and Sons, Inc., New York, N. Y., 1954, p. 277, point out that hydrogenation with palladium causes debenzylation in tertiary amines containing one benzyl group.

(9) (a) C. F. Winans and H. Adkins, THIS JOURNAL, **55,** 4167 (1933), comment on the difficulty of developing a satisfactory method for hydrogenating α-aminonitriles; (b) H. Reihlen, *et al.*, *Ann.*, **493,** 20 (1932), have shown that α-aminonitriles liberate hydrogen cyanide under hydrogenation conditions.

(10) R. A. Turner, THIS JOURNAL, **68,** 1607 (1946), hydrogenated the nitrile at 78° and 70 atmospheres with Raney nickel and obtained a 47% yield of amine.

ration of 3-methoxypropylamine for similar reasons.

In all the reductions described in this study at least five molar equivalents of ammonia are necessary. With this amount of ammonia, formation of secondary amine is kept at a low level (see Table III). When less is used the yield of primary amine decreases. This would appear to be in agreement with the proposals outlined by von Braun.[11]

Acknowledgments.—The author is indebted to Mr. E. F. Fischer and the preparations group and other members of this Laboratory for the nitriles used in this investigation. He also expresses gratitude to Messrs. G. R. Stone for the high pressure hydrogenations and E. F. Shelberg and O. Kolsto and associates for the microanalyses, and W. Washburn for the infrared analyses.

Experimental

Substituted α-Aminonitriles. 4-Methylpiperazinoacetonitrile.—The method of Luten[12] was used to prepare 4-methylpiperazinoacetonitrile. It was obtained as an oil boiling at 128–135° (25 mm.). On redistillation the fraction collected at 113–114° (13 mm.) solidified and melted at 45°.

Anal. Calcd. for $C_7H_{13}N_3$: N, 30.19. Found: N, 30.08.

Dimethylaminoacetonitrile and 1-piperidinoacetonitrile were prepared in a similar manner.

4-*p*-Chlorobenzhydrylpiperazinoacetonitrile.[13]—A mixture of 20.2 g. (0.2 mole) of triethylamine and 15.0 g. (0.2 mole) of chloroacetonitrile was added to a solution of 57.2 g. (0.2 mole) of *p*-chlorobenzhydrylpiperazine in 150 cc. of dry ether. The solution was then refluxed for two hours and cooled. After removal of triethylamine hydrochloride the solution was concentrated. The viscous mass obtained was stored in the cold for several days until it solidified. After recrystallization from absolute alcohol a 66% yield of product melting at 93–94° was obtained.

Anal. Calcd. for $C_{19}H_{20}ClN_3$: C, 70.03; H, 6.19. Found: C, 69.96; H, 6.08.

N-Benzyl-N-methylaminoacetonitrile.[14]—A solution of 25.4 g. (0.2 mole) of benzyl chloride in 50 cc. of ethyl methyl ketone was added to a mixture of 14.0 g. (0.2 mole) of N-methylaminoacetonitrile and 21.0 g. (0.25 mole) of sodium bicarbonate in 200 cc. of ethyl methyl ketone kept below 10°. When the addition was complete the mixture was refluxed for 6 hours and filtered. After removal of the solvent the residue was distilled. The product boiled at 117–119° (7 mm.), $n^{25}D$ 1.5150, and weighed 20.6 g. (64% yield).

Anal. Calcd. for $C_{10}H_{12}N_2$: C, 74.96; H, 7.55. Found: C, 75.30; H, 8.06.

β-Aminonitriles. β-4-Methylpiperazinopropionitrile was prepared from N-methylpiperazine and acrylonitrile by the method of Jacob and Robert.[15] An 89% yield of product boiling at 140–143° (25 mm.), $n^{25}D$ 1.4751, was obtained.

Anal. Calcd. for $C_8H_{15}N_3$: N, 27.42. Found: N, 27.60.

The preparation of β-benzylmethylaminopropionitrile has been described.[16]

3-Dimethylaminobutyronitrile and 4-dimethylaminovaleronitrile were prepared by reaction of the corresponding chloronitriles with dimethylamine.

β-Cyanoethyl Ethers.[17]—The followlng procedure is an example of the method used to prepare the intermediate β-cyanoethyl ethers.

β-Cycloheptyloxypropionitrile.—Acrylonitrile (16 g., 0.3 mole) was added dropwise to 35 g. (0.3 mole) of cycloheptanol containing 0.1 g. of sodium methylate. After the exothermic reaction had subsided the mixture was stirred and heated on the steam-bath for one hour and left to stand at room temperature overnight. After acidification with a small amount of acetic acid it was distilled. The fraction boiling at 110–111° (3.2 mm.), $n^{25}D$ 1.4622, was collected. The weight (37.6 g.) corresponded to a 76% yield.

Anal. Calcd. for $C_{10}H_{17}NO$: C, 71.80; H, 10.25; N, 8.36. Found: C, 71.90; H, 10.35; N, 8.48.

β-Cyclopentyloxypropionitrile boiling at 77–79° (1.3 mm.), $n^{25}D$ 1.4477, was obtained in 80% yield.

Anal. Calcd. for $C_8H_{13}NO$: C, 69.03; H, 9.41; N, 10.16. Found: C, 69.37; H, 9.56; N, 10.15.

β-Cyclohexylmethoxypropionitrile was obtained in 85% yield. It boiled at 109° (5 mm.), $n^{25}D$ 1.4545.

Anal. Calcd. for $C_{10}H_{17}NO$: C, 71.80; H, 10.25; N, 8.36. Found: C, 71.59; H, 10.09; N, 8.49.

β-Methoxypropionitrile and β-hexyloxypropionitrile have been described before.[18]

Procedure (a) is an example of the method used to prepare the compounds in Tables I and II except where higher pressure and no solvent are noted.

Tryptamine. (a) **Hydrogenation of 3-Indoleacetonitrile with Rhodium Catalyst and Ammonia.**—3-Indoleacetonitrile (23.4 g., 0.15 mole) was dissolved in 170 cc. of 10% ethanolic ammonia (1.0 mole). Four grams of 5% rhodiumon-alumina[19] was added and the mixture was hydrogenated in a Parr shaker under 2.5 atmospheres pressure. Uptake for 0.3 mole of hydrogen was completed in less than two hours. The solution was filtered to remove the catalyst and the filtrate was combined with that of a second batch of the same size. The solvent was removed and the residue distilled. Tryptamine was obtained in a 78.2% yield. It boiled at 165–170° (1.2 mm.) and solidified and melted at 112° (lit.[3] m.p. 116°). It was further identified by infrared analysis.

(b) **Hydrogenation without Ammonia.**—A solution of 21.8 g. (0.14 mole) of 3-indoleacetonitrile in 100 cc. of methanol was hydrogenated under 2 atmospheres pressure in the presence of 4.4 g. of 5% rhodium-on-alumina. When hydrogen uptake was complete the catalyst was removed by filtration. The solvent was removed and the residue subjected to distillation. Very little tryptamine was obtained. The residue was identified as bis-(β-3-indolylethyl)-amine by properties described in the next experiment.

(c) **Bis-(β-3-indolylethyl)-amine Hydrochloride.**—Sodium metal (0.2 g.) was added to the same amount of materials in experiment (b). Hydrogenation was carried out under the same conditions. The solution was filtered from the catalyst and the filtrate concentrated to dryness. The residue was dissolved in 100 cc. of methanol and treated with a slight excess of alcoholic hydrogen chloride. The solution was diluted with 500 cc. of ether and allowed to stand. The precipitate that formed was filtered. On further standing a second crop of crystals was obtained. The first crop weighed 9.4 g. After recrystallization from dilute ethanol it melted at 289–290°. Further recrystallization from hot water raised the melting point to 290–292°.

Anal. Calcd. for $C_{20}H_{21}N_3 \cdot HCl$: C, 70.67; H, 6.52; N, 12.36; Cl, 10.43. Found: C, 69.79; H, 6.39; N, 12.58; Cl, 9.76.

A glassy like base was obtained from the hydrochloride salt by treatment with sodium hydroxide solution. It was shown to be secondary amine by infrared analysis.

The second crop of material weighed 2.5 g. and melted at 240–245°. It was found to be impure tryptamine hydrochloride.

(d) **Alternate Preparation of Tryptamine.**—The same procedure was followed as in experiment (a), but instead of subjecting it to distillation the residue from a 0.3-mole run was treated with 300 cc. of water containing 15 cc. of concentrated hydrochloric acid. The mixture was stirred for a short time and filtered. The insoluble portion amounting to about 20 g. (19.6%) was identified as the hydrochloride of the secondary amine described in experiment (c).

The acidic filtrate was made basic and allowed to stand. The precipitate was then filtered and washed well with cold

(11) J. von Braun, G. Blessing and F. Zobel, *Ber.*, **56**, 1988 (1923).

(12) Method I, D. B. Luten, Jr., *J. Org. Chem.*, **3**, 588 (1937).

(13) This compound was prepared and characterized by Mr. H. B. Wright of the Organic Research Division of this Laboratory.

(14) This compound was prepared and characterized by Mr. Arthur A. Alter of the Organic Research Division of this Laboratory.

(15) R. M. Jacob and J. Robert, U. S. Patent 2,534,744.

(16) J. A. King and F. H. McMillan, THIS JOURNAL, **68**, 1468 (1946).

(17) This group of compounds were prepared and characterized by Dr. J. H. Short of the Organic Research Division of this Laboratory.

(18) A. I. Vogel, W. T. Cresswell, G. H. Jeffery and J. Leicester, *J. Chem. Soc.*, 514 (1952).

(19) The rhodium catalyst was supplied by the Baker and Co. Division of Engelhard Industries, 113 Astor Street, Newark, N. J.

water and dried. After thorough drying the crude tryptamine melted at 106° and weighed 34 g. (71%). After recrystallization from Skelly B the melting point rose to 114°. A hydrochloride salt made from the crude base melted at 243–244° (lit.[3] 245°).

6-(*p*-Acetylaminobenzenesulfonamido)-hexylamine Hydrochloride. (a) **1-Cyano-5-(*p*-nitrobenzenesulfonamido)-pentane.**[14]—A solution of 9.8 g. (0.1 mole) of α-aminocapronitrile in 25 cc. of chloroform was added dropwise with stirring to a solution of 22.2 g. (0.1 mole) of *p*-nitrobenzenesulfonyl chloride in 100 cc. of chloroform. Thereafter a solution of 4.0 g. (0.1 mole) of sodium hydroxide in 25 cc. of water was added dropwise and the stirring continued for two hours. The chloroform layer was separated and washed with water and then distilled without drying. The residual solid was first recrystallized from aqueous dimethylformamide and further recrystallized from methanol. After thorough drying 19.4 g. (58.2%) of product melting at 85–87° was obtained.

Anal. Calcd. for $C_{12}H_{15}N_3O_4S$: C, 48.45; H, 5.09; N, 14.14. Found: C, 48.78; H, 5.16; N, 14.16.

(b) **1-Cyano-5-(*p*-acetylaminobenzenesulfonamido)-pentane.**—Fifteen and two-tenths grams (0.051-mole) of 1-cyano-5-(*p*-nitrobenzenesulfonamido)-pentane in 200 cc. of ethyl acetate containing 1 cc. of acetic anhydride was reduced in the presence of 1.5 g. of 5% palladium-on-charcoal. The crude product after removal of solvent was an oil and would not solidify after storage in the cold for three days.

(c) **6-(*p*-Acetylaminobenzenesulfonamido)-hexylamine Hydrochloride.**—Approximately 0.05 mole of the oily nitrile from experiment (b) was dissolved in 100 cc. of ethanol containing 5 g. of ammonia. Three grams of 5% rhodium-on-alumina was added and the mixture hydrogenated under 2 atmospheres pressure. Uptake was rapid and was completed in less than one hour. The solution was filtered from the catalyst and concentrated to dryness. The oily residue was treated with 0.075 mole of alcoholic hydrogen chloride and the resulting solution evaporated to dryness. The residual mass was recrystallized from absolute alcohol containing some hydrogen chloride. The salt obtained in 71.5% yield decomposed at 210–215°.

Anal. Calcd. for $C_{14}H_{23}N_3O_3S\cdot HCl$: C, 48.05; H, 6.91. Found: C, 47.43; H, 6.76.

NORTH CHICAGO, ILL.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, STATE UNIVERSITY OF IOWA]

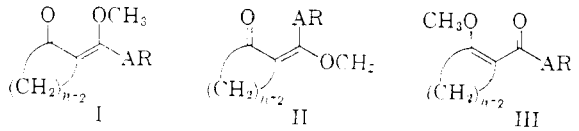
β-Diketones. I. Synthesis and Reactions of Some 2-Benzoylcyclanones[1]

BY R. D. CAMPBELL AND H. M. GILOW[2]

RECEIVED SEPTEMBER 26, 1959

2-(*o*-Chlorobenzoyl)-cyclohexanone (IV) reacted with diazomethane to form two isomeric methyl ethers, 2-(α-methoxy-*o*-chlorobenzal)-cyclohexanone (V) and 1-(*o*-chlorobenzoyl)-2-methoxycyclohexene (VI). The structures of the methyl ethers were identified by the reduction of the carbonyl group with sodium borohydride, followed by cleavage of the methyl ether and dehydration to form 1-(*o*-chlorobenzoyl)-cyclohexene and 2-(*o*-chlorobenzal)-cyclohexanone, respectively. In the process of studying the reaction of diazomethane, basic cleavage and enol content of some 1,3-diketones nine new 2-benzoylcyclanones were prepared.

Reactions with Diazomethane.—1,3-Diketones are known to react with diazomethane to form the methyl ether of the enol form.[3–6] If an unsymmetrical 1,3-diketone is treated with diazomethane, at least two different methyl ethers may be formed. For example, an aroylcyclanone may form three different methyl ethers (I, II, III) provided the ring is not too large.



I II III

V (AR = *o*-ClC_6H_4–, *n* = 6) VI (AR = *o*-ClC_6H_4–, *n* = 6)

2-(*o*-Chlorobenzoyl)-cyclohexanone (IV) reacted with a methanol–ether solution of diazomethane to form 2-(α-methoxy-*o*-chlorobenzal)-cyclohexanone (V) and 1-(*o*-chlorobenzoyl)-2-methoxycyclohexene (VI) in a 74.1 and 25.9% yield, respectively. Whether V exists as a *cis* or *trans* form or a mixture of the two was not determined. However it seemed probable that the product obtained was the *cis* compound (corresponding to structure I). On the basis of spectral evidence to be discussed in a subsequent article, the enol exists as a *cis* chelate. Vigorous evolution of nitrogen was observed when the enol reacted with diazomethane in methanol–ether. When no methanol is present the reaction is slow. It has been suggested[7] that the methanol solvates the enol to break up the chelate ring, and permit reaction with the enolic hydrogen. It seems probable that the solvation and the reaction of the enol with diazomethane are faster by an order of magnitude or more than the tautomeric isomerization necessary to give the *trans* enol. Enol ether VI is a white solid which changes to a yellow oil on standing. Enol ether V is a yellow oil. When dissolved in methanol, both V and VI give a violet color with methanolic ferric chloride on standing. This is due to ether cleavage catalyzed by the reagent. Both ethers can be cleaved readily with dilute hydrochloric acid to form IV. The isolation of V and VI in 74.1 and 25.9% yield, respectively, does not necessarily indicate that the enols from which they must have been formed existed in the same ratio, since diazomethane may have reacted somewhat faster with one form than the other.[5] However, this does indicate that both enolic modifications of IV do exist, probably in roughly the ratio indicated.

The structure of methyl ether VI was established by the selective reduction of the carbonyl group to the hydroxyl group with sodium borohydride.[8]

(1) Taken in part from the Ph.D. Thesis of H. M. Gilow, August, 1959.

(2) Ethyl Corporation Fellow, 1958–1959.

(3) B. Eistert, R. Weygand and E. Csendes, *Ber.*, **84**, 745 (1951).

(4) B. Eistert and W. Reiss, *ibid.*, **87**, 108 (1954).

(5) B. Eistert and E. Merkel, *ibid.*, **86**, 895 (1953).

(6) B. Eistert, E. Merkel and W. Reiss, *ibid.*, **87**, 1513 (1954).

(7) B. Eistert, R. Arndt, L. Lowe and E. Ayca, *ibid.*, **84**, 156 (1951).

(8) S. W. Chaikin and W. G. Brown, THIS JOURNAL, **71**, 122 (1949).