The main reaction product (6.8 g.) was crystallized from alcohol to give 6.0 g., m.p. 168.5–170°.

(b) *Condensation of 2-N,N-dimethylamino-3-nitrofluorene with o-nitrosotoluene*[12] *and hydrolysis of the azomethine.* In a procedure similar to Bergmann's,[18] using 2 drops of piperidine as catalyst, 2.24 g. (0.01 mole) of 2-dimethylamino-3-nitrofluorene and 1.21 g. (0.01 mole) of *o*-nitrosotoluene (Aldrich Chemical Co., m.p. 67–72°) were refluxed in 150 ml. of alcohol for 5 hr. and the alcohol boiled down to 60–70 ml. Upon standing, a tarry mass of crystals formed which appeared difficult to work with. After decanting the solution, fresh alcohol was added and 5 ml. of concd. hydrochloric acid. This mixture was refluxed for 30 min. and allowed to cool. The resulting crystalline precipitate was filtered and dried, 0.5 g., m.p. 160–167° (softening *ca.* 150°). Two recrystallizations from ethanol (Darco) and one from methanol gave a sample melting at 167–169°, with initial melting at 160° and immediate resolidification. Nitrogen analysis showed that one molecule of methanol was included. Drying at 125° for 3 hr. in a vacuum raised the melting point to 169–170° with melting or softening at a lower temperature.

Anal. Calcd. for $C_{15}H_{12}N_2O_3$: N, 10.44. Found: N, 10.28.

A mixture melting point with the nitration product from (a) was undepressed.

An attempt to isolate the intermediate azomethine, *N-9-(2-dimethylamino-3-nitrofluorenylidene)-o-toluidine,* was more successful using sodium methylate (0.65 g.) as a catalyst with 0.01 mole of each of the reactants in boiling alcohol for 4 hr. The initial semicrystalline tar, after decantation and evaporation of residual solvent, amounted to 2.1 g. Upon extraction with hot methanol, filtration and cooling of the filtrate, 0.4 g. of a bright red substance was obtained melting at 125–133°. Two more recrystallizations from methanol raised the melting point to 129.5–131.5°.

Anal. Calcd. for $C_{22}H_{19}N_3O_2$: C, 73.93; H, 5.36; N, 11.76. Found: C, 73.74; H, 5.12; N, 11.65.

2-N,N-Dimethylamino-3-aminofluoren-9-ol. Reduction of *2-N,N-dimethylamino-3-nitrofluoren-9-ol*[19] with Raney nickel and hydrazine hydrate[6] gave a 95% yield of the 3-amino derivative, m.p. 129–133°. Two recrystallizations from ligroin (b.p. 30–60°) gave an analytical sample, m.p. 132–133°.

Anal. Calcd. for $C_{15}H_{16}N_2O$: C, 74.97; H, 6.71; N, 11.66. Found: C, 74.84; H, 6.77; N, 11.83.

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(18) E. D. Bergmann, *J. Chem. Soc.*, 1628 (1937).

(19) This was made by Mr. H. L. Pan, as an extension of our earlier study,[13] in high yield by sodium borohydride reduction in methanol, m.p. 126–127°.

Anal. Calcd. for $C_{15}H_{14}N_2O_3$: C, 66.65; H, 5.22; N, 10.37. Found: C, 66.79; H, 5.50; N, 10.50.

[CONTRIBUTION FROM THE RESEARCH LABORATORIES, AEROJET-GENERAL CORPORATION]

Preparation of ω-Aminoalkyl Secondary Nitramines

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Received October 23, 1959

A method was developed for selectively converting secondary amines to the corresponding nitramines in the presence of primary amino groups. The method consists of three steps: (1) complete acetylation of the amino groups, (2) selective nitrolysis of the amido group by treatment of the acetylated amine with a nitric acid-trifluoroacetic anhydride mixture or with nitrogen pentoxide in a suitable solvent, and (3) hydrolysis of the diacetamido group. In this manner, *N*-methyl-1,3-propylenediamine, diethylenetriamine, and triethylenetetramine were converted to the hydrochloride salts of *N*-methyl-*N*-nitro-1,3-propylenediamine, 3-nitraza-1,5-pentanediamine, and 3,6-dinitraza-1,8-octanediamine.

3-Nitrazabutylamine was the first ω-aminoalkyl secondary nitramine to be prepared.[3] It was synthesized by a six-step process starting with 4-azapentanonitrile. It was of interest to find a general method for preparing ω-aminoalkyl secondary nitramines which was more direct and did not involve the preparation of the hazardous azide.

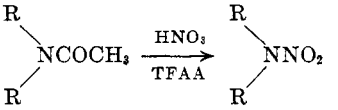
The most direct route would be the conversion of an ω-aminoalkyl imine to the corresponding nitramine:

$$\underset{\text{H}}{\overset{|}{\text{R}}}\text{NCH}_2\text{CH}_2\text{NH}_2 \longrightarrow \underset{\text{NO}_2}{\overset{|}{\text{R}}}\text{NCH}_2\text{CH}_2\text{NH}_2$$

However, direct nitration is not feasible, as both the primary and secondary amino groups would be attacked. To circumvent this, it would be necessary to block the primary amino group, nitrate the secondary amine without affecting the blocking group or groups, and finally regenerate the primary amino group.

In the first approach the Schiff bases of diethylenetriamine with benzaldehyde and salicylaldehyde were prepared. The Schiff base from benzaldehyde was unstable to nitric acid, but it was possible to prepare the nitric acid salt of the salicylaldehyde derivative. However, attempts to dehydrate this salt to the corresponding nitramine were unsuccessful, this approach was abandoned.

Another route to this problem was suggested by the facile nitrolysis of *N,N*-dialkyl acetamides in trifluoroacetic anhydride (TFAA):[4]



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(2) Present address: Shell Development Company, Modesto, California.

(3) M. B. Frankel and Karl Klager, *J. Am. Chem. Soc.* **78**, 5428 (1956).

(4) J. H. Robson and J. Reinhart, *J. Am. Chem. Soc.* **77**, 2453 (1955).

Inasmuch as *N,N*-dialkyl acetamides are stronger bases than *N*-alkyl diacetamides, it might be expected that the latter would be less susceptible to nitrolysis. In order to test this hypothesis, *N*-butyldiacetamide was prepared and an attempt to nitrolyze it to *N*-acetylbutylnitramine was made:

$$C_4H_9N(COCH_3)_2 \xrightarrow[TFAA]{HNO_3} C_4H_9\overset{NO_2}{\underset{|}{N}}COCH_3$$

As expected, this nitrolysis did not take place. On the basis of these results, it then seemed feasible to prepare ω-aminoalkyl secondary nitramines in three steps: (1) complete acetylation of an ω-aminoalkyl imine, (2) selective nitrolysis of the amide group, and (3) hydrolysis of the diacetamido groups:

$$\overset{H}{\underset{|}{R}}N(CH_2)_nNH_2 \xrightarrow{(CH_3CO)_2O} \overset{COCH_3}{\underset{|}{R}}N(CH_2)_nN(COCH_3)_2 \xrightarrow[TFAA]{HNO_3}$$

Ia. R = CH_3, n = 3 II
Ib. R = $CH_2CH_2NH_2$, n = 2
Ic. R = $CH_2CH_2NHCH_2CH_2NH_2$, n = 2

$$\overset{NO_2}{\underset{|}{R}}N(CH_2)_nN(COCH_3)_2 \xrightarrow{HCl} \overset{NO_2}{\underset{|}{R}}N(CH_2)_nNH_2.HCl$$

III IV

The acetylation reactions were carried out by treating the amines with an excess of acetic anhydride at 10–15°. After the initial exothermic reaction was completed, the reaction mixture was refluxed under a fractionating column until the theoretical amount of acetic acid was collected. In this manner, *N*-methyl-*N,N',N'*-triacetyl-1,3-propylenediamine (IIa), *N,N,N',N',N''*-pentaacetyldiethylenetriamine (IIb), and *N,N,N',N',N'',N'''*-hexaacetyltriethylenetetramine (IIc) were prepared.

The nitrolysis of *N,N*-dialkyl acetamides, using absolute nitric acid and trifluoroacetic anhydride, was rapid, being complete in twenty minutes at −5°.[4] Robson and Reinhart[4] reported that the nitrolysis was retarded easily both by steric hindrance from the *N*-alkyl group and by electronegative substituents. This was proved in our work, where it was found that the nitrolysis of IIa, IIb, and IIc was very slow.

A series of experiments were carried out in which the nitrolysis mixture of IIb, nitric acid, and trifluoroacetic anhydride was allowed to stand at 0° and −21° for varying lengths of time. Optimum yields of *N,N,N',N'*-tetraacetyl-*N''*-nitrodiethylenetriamine (IIIb) were obtained after 65 hours at 0° (91.0%) and 168 hours at −21° (87.6%). Shorter reaction times gave mixtures of starting material and product, while higher temperatures gave low yields. It was of interest to investigate other methods for carrying out this nitrolysis reaction. Inasmuch as the principal product of reaction between nitric acid and trifluoroacetic anhydride is nitrogen pentoxide, the direct use of nitrogen pentoxide, prepared from nitric acid and phosphorus pentoxide, was investigated. Treatment of IIb with a solution of nitrogen pentoxide in methylene chloride at 0° for 65 hours gave a mixture of predominately starting material and some product. In order to determine whether this nitrolysis reaction would proceed more readily in a polar solvent, nitric acid, sulfuric acid, sulfur dioxide, dichloroacetic acid, and trifluoroacetic acid were tried as solvents. No product was obtained with either absolute nitric acid or concentrated sulfuric acid. Sulfur dioxide, dichloroacetic acid, and trifluoroacetic acid gave IIb in yields of 68.2%, 71.4%, and 80.8%, respectively. The use of nitric acid and trichloroacetic anhydride as a nitrolysis medium gave only a 11.6% yield of product. *N*-Methyl-*N*-nitro-*N,N'*-diacetyl-1,3-propylenediamine (IIIa) and *N,N,N',N'*-tetraacetyl-*N'',N'''*-dinitrotriethylenetriamine (IIIc) were prepared in 91.0% and 85.7% yields, respectively, using a nitrolysis mixture of nitric acid and trifluoroacetic anhydride.

Hydrolysis of IIIa, IIIb, and IIIc with concentrated hydrochloric acid took place readily with the formation of 4-nitraza-1-pentylamine hydrochloride (IVa), 3-nitraza-1,5-pentanediamine dihydrochloride (IVb), and 3,6-dinitraza-1,8-octanediamine dihydrochloride (IVc). The results are summarized in Table I.

EXPERIMENTAL[5,6]

N,N'-Disalicylidene-3-aza-1,5-pentanediamine. A mixture of 12.4 g. (0.12 mole) of diethylenetriamine, 22.4 g. (0.18 mole) of salicylaldehyde, and 70 ml. of dry benzene was refluxed under a Dean-Stark trap. After 4 hr. the theoretical amount of water was collected. The solution was concentrated *in vacuo* and the residual oil was poured into water. The organic layer was extracted with methylene chloride, dried, and concentrated to give 23.7 g. (82.9%) of viscous yellow oil, n_D^{29} 1.6134.

In a similar manner *N,N'*-dibenzylidene 3-aza-1,5-pentanediamine was prepared in quantitative yield after only 1 hr. of refluxing.

Nitric acid salt of N,N'-disalicylidene-3-aza-1,5-pentanediamine. A solution 3.1 g. (0.01 mole) of *N,N'*-disalicylidene 3-aza-1,5-pentanediamine in 25 ml. of methanol was cooled in an ice-bath and 0.63 g. (0.01 mole) of 99% nitric acid was added. A yellow solid precipitated; it was collected, washed with ether, and dried to give 3.4 g. (91.0%), m.p. 152–155°, of product. Recrystallization from methanol gave yellow needles, m.p. 153–155°.

Anal. Calcd. for $C_{18}H_{22}N_4O_5$: C, 57.74; H, 5.92; N, 14.97. Found: C, 57.75; H, 5.79; N, 15.38.

Attempted dehydration of the nitric acid salt of N,N'-disalicylidene-3-aza-1,5-pentanediamine. To 175 ml. of acetic anhydride was simultaneously added 112.2 g. (0.3 mole) of the nitric acid salt of *N,N'*-disalicylidene 3-aza-1,5-pentanediamine and 1.5 g. (0.015 mole) of 37% hydrochloric acid, at ambient temperature. After 2 hr. the solid had dissolved to give a brown solution. The mixture was hydrolyzed by the addition of 300 ml. of water which caused the formation of two layers. The aqueous layer was separated and ex-

(5) All melting points are uncorrected.

(6) Microanalyses by Dr. A. Elek, Elek Microanalytical Laboratory, 4763 W. Adams Blvd., Los Angeles, Calif.

TABLE I

NITROLYSIS AND HYDROLYSIS OF IIIa, IIIb, AND IIIc

Acetylated Amine	M.P.	Recryst. Solvent	Yield, %	Formula	Analyses, % Calcd. C	H	N	Cl	Found C	H	N	Cl
$CH_3N(COCH_3)CH_2CH_2CH_2N(COCH_3)_2$	[a]		90.7	$C_{10}H_{18}N_2O_3$	56.05	8.47	13.08		55.69	8.56	12.48	
$N(COCH_3)[CH_2CH_2N(COCH_3)_2]_2$	109–110	Isopropanol	52.7	$C_{14}H_{23}N_3O_5$	53.66	7.40	13.41		53.37	7.20	12.99	
$[CH_2N(COCH_3)CH_2CH_2N(COCH_3)_2]_2$	150–151	Ethanol	72.0	$C_{18}H_{30}N_4O_6$	54.26	7.59	14.06		54.27	7.82	13.82	
Nitrolysis Product												
$CH_3N(NO_2)CH_2CH_2CH_2N(COCH_3)_2$	[b]		91.6[c]	$C_8H_{15}N_3O_4$								
$N(NO_2)[CH_2CH_2N(COCH_3)_2]_2$	122–123	Ethanol	91.0[d] 87.6[e]	$C_{12}H_{20}N_4O_6$	45.56	6.37	17.71		46.12	6.47	17.58	
$[CH_2N(NO_2)CH_2CH_2N(COCH_3)_2]_2$	112–113	Methanol	85.7[f]	$C_{14}H_{24}N_6O_8$	41.58	5.98	20.79		41.53	5.90	20.56	
Nitrazamine Hydrochloride												
$CH_3N(NO_2)CH_2CH_2CH_2NH_2\cdot HCl$	123–124	Ethanol	67.8	$C_4H_{12}ClN_3O_2$	28.34	7.14	24.79	20.92	28.68	7.50	24.24	21.21
$N(NO_2)[CH_2CH_2NH_2\cdot HCl]_2$	261–263	78% Ethanol	89.1	$C_4H_{14}Cl_2N_4O_2$	21.64	6.31	25.24	31.94	21.61	6.56	25.77	32.25
$[CH_2N(NO_2)CH_2CH_2NH_2\cdot HCl]_2$	285–295	Water	90.0	$C_6H_{18}Cl_2N_6O_4$	23.31	5.87	27.19		23.77	5.99	26.89	

[a] B.p. 153°/0.5 mm., n_D^{25} 1.4862. [b] Could not be distilled without decomposition, n_D^{25} 1.5004. [c] Reaction time of 7 days at −20°. [d] Reaction time of 65 hr. at 0°. [e] Reaction time of 168 hr. at −20°. [f] Reaction time of 7 days at −20° and 3 days longer at 0°.

tracted with methylene chloride. The extracts were combined with the water insoluble layer, concentrated and fractionated through a Holzman column to give 36.1 g. of salicylaldehyde, b.p. 38–40°/0.55 mm., n_D^{25} 1.5701; and 16.8 g. of a yellow liquid, b.p. 88–90°/0.25 mm., n_D^{25} 1.5309, whose analyses corresponded to 2-acetoxybenzaldehyde.

Anal. Calcd. for $C_9H_8O_3$: C, 65.81; H, 4.91. Found: C, 65.91; H, 5.02.

The aqueous phase from the reaction mixture was made basic and extracted with methylene chloride for 12 hr. on a continuous extractor. Concentration of the methylene chloride solution left no residue.

N,N,N′,N′,N″-Pentaacetyldiethylenetriamine (IIb). To 4080 g. (40.0 moles) of acetic anhydride was added, dropwise, 515 g. (5.0 moles) of redistilled diethylenetriamine, keeping the temperature at 10–15° by external cooling. The solution was warmed to room temperature and then refluxed under a 20 plate Oldershaw column for 30 hr., during which time the theoretical amount of acetic acid was collected. The residue was concentrated *in vacuo*, leaving a viscous dark brown oil which solidified. The product was recrystallized from 3 l. of 2-propanol to give 823 g. (52.7%) of light yellow crystals, m.p. 106–108°. A second recrystallization gave a white solid; m.p. 109–110°.

The nitrolysis of N,N,N′,N′,N″-pentaacetyldiethylenetriamine. A. *With nitric acid and trifluoroacetic anhydride.* To 80 ml. (0.58 mole) of trifluoroacetic anhydride was added dropwise 16.8 ml. (0.4 mole) of 98–99% technical nitric acid, keeping the temperature at −10 to −20°. Then 31.3 g. (0.1 mole) of *N,N,N′,N′,N″*-pentaacetyldiethylenetriamine was added. The solid dissolved and the solution was allowed to stand in an ice-bath for 65 hr. The reaction mixture was concentrated *in vacuo*. The residue was dissolved in methylene chloride, washed with saturated sodium carbonate solution, dried, and concentrated, leaving 28.8 g. (91.0%) of white solid, m.p. 120–122°. Recrystallization from ethanol raised the melting point to 122–123°.

B. *With nitrogen pentoxide in trifluoroacetic acid.* The Inorganic Synthesis preparation of nitrogen pentoxide[7] gives a yield of 50% and the procedure is only applicable for small-scale runs. This process was modified to give improved yields on a larger scale. In a 2-l. glass resin pot fitted with a sealed stainless steel horseshoe-shaped stirrer driven by an air motor, solid addition flask, and drying tube, was placed 336 ml. (8.0 moles) of 98–99% technical nitric acid. The acid was cooled to −20 to −10° and 426 g. (3.0 moles) of phosphorus pentoxide was added portionwise from the solid addition flask, keeping the temperature about −10° by external cooling. After the addition was complete, the reaction mixture was allowed to warm to room temperature. The addition flask was replaced with a distillation head and receiver which was connected through a drying tube to the water aspirator. The reaction mixture was then stirred under vacuum at ambient temperature for 4 hr. The nitrogen pentoxide which was collected in the receiver was light yellow to white needles, the yield was 333 g. (77%).

A mixture of 6.26 g. (0.02 mole) of *N,N,N′,N′,N″*-pentaacetyldiethylenetriamine, 12.0 g. (0.11 mole) of nitrogen pentoxide, and 10 ml. (0.16 mole) of trifluoroacetic acid was allowed to stand in an ice-bath for 43 hr., and then concentrated *in vacuo*. Working up in the same manner as described in A., above, there was obtained 5.1 g. (80.8%) yield of product, m.p. 121–122°.

C. *With nitrogen pentoxide in sulfur dioxide.* The procedure was the same as in B., above, except that a glass pressure bottle was used for the reaction vessel.

D. *With nitrogen pentoxide in dichloroacetic acid.* A mixture of 6.26 g. (0.02 mole) of *N,N,N′,N′,N″*-pentaacetyldiethylenetriamine, 10.8 g. (0.1 mole) of nitrogen pentoxide, and 38.7 g. (0.3 mole) of dichloroacetic acid was allowed to stand in an ice-bath for 24 hr. The reaction mixture was poured on ice and a saturated sodium carbonate solution was added until the resulting *p*H of the solution was 10. The product was collected and recrystallized from ethanol to give 4.52 g. (71.4%) of white crystals, m.p. 118–120°.

3-Nitraza-1,5-pentanediamine dihydrochloride (IId). A mixture of 31.6 g. (0.1 mole) of *N,N,N′,N′*-tetraacetyl-*N″*-nitrodiethylenetriamine and 50 ml. of 37% hydrochloric acid was refluxed for 4 hr. The reaction mixture was cooled and diluted with 50 ml. of methanol. The product was collected and dried to give 19.7 g. (89.1%) of white crystals, m.p. 259–263° dec. Recrystallization from 78% ethanol raised the melting point to 261–263° dec.

Acknowledgment. We are indebted to the Bureau of Ordnance for the financial support of this work and to Mr. E. R. Wilson for aid in the experimental work.

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[CONTRIBUTION FROM THE REGA INSTITUTE, UNIVERSITY OF LOUVAIN]

Phenoxazines. I. Ring-Substituted Derivatives

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Received October 30, 1959

Several 2-acylphenoxazines have been prepared by a Friedel-Crafts reaction. The structure of these products is based on the examination of the infrared and ultraviolet spectra of 2- and 3-acetyl-10-ethylphenoxazine. Other 2-substituted phenoxazines also were synthesized.

Several C-monoacylphenoxazines were prepared by a Friedel-Crafts reaction with 10-acetylphenoxazine (I). Because no method is known for the transformation of phenoxazines into substances of known structure, the formulation of our reaction products is based on the infrared bands typical for substituted benzene derivatives and supported by a comparison of their ultraviolet spectra with those previously reported for phenothiazine.

Unsymmetrical trisubstituted benzene structures show a characteristic band in the 12.0–12.5 μ region, while vicinal trisubstituted derivatives have a band in the 12.5–13.15 μ region.[1,2,3] It has been shown that these bands are present in phenothi-