In another experiment like the foregoing except that the acidic material was extracted with sodium bicarbonate, the acidic material (VIII) which was only soluble in sodium hydroxide was a tan solid, m.p. 135–143°, weight 0.455 g. (14%). The yield of 2-nitro-2′-acetylbiphenyl, m.p. 58–61°, was 1.47 g. (51%).

Repeated recrystallizations of VIII from ethanol yielded cream-colored crystals, m.p. 144–145.5°; infrared absorption 4.4 CN, 5.98 C=O, 6.3, 6.58 $NO_2$, 7.40 $NO_2$, 7.8 μ (chloroform).

*Anal.* Calcd. for $C_{15}H_{10}N_2O_3$: C, 67.66; H, 3.79; N, 10.52. Found: C, 67.72; H, 3.59; N, 10.68.

*2-Acetyl-2′-nitrobiphenyl* (XII). The light brown solid, m.p. 58–61°, obtained during the preparation of VIII was recrystallized three times from ethanol to yield nearly white crystals of XII, m.p. 60–61°.

*Anal.* Calcd. for $C_{14}H_{11}NO_3$: C, 69.70; H, 4.60; N, 5.81. Found: C, 69.60, 69.83; H, 4.57, 4.62; N, 5.83, 5.90.

The 2,4-dinitrophenylhydrazone of XII after two recrystallizations from ethanol–ethyl acetate consisted of orange crystals, m.p. 191–192.5°.

*Anal.* Calcd. for $C_{20}H_{15}N_5O_6$: N, 16.62. Found: N, 16.88, 16.78.

The semicarbazone of XII after three crystallizations from aqueous ethanol was a white powder, m.p. 214–216° dec.

*Anal.* Calcd. for $C_{15}H_{14}N_4O_3$: N, 18.78. Found: N, 18.78, 18.97.

MORGANTOWN, W. VA.

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[CONTRIBUTION FROM THE CHEMISTRY RESEARCH LABORATORY OF THE DEPARTMENT OF SURGERY,
UNIVERSITY OF WASHINGTON SCHOOL OF MEDICINE]

# Derivatives of Fluorene. VII. New Mono and Dinitro Compounds and Some of Their Reactions[1]

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New mono and dinitro derivatives of substituted fluorenes are reported with some improved routes to known compounds. Usefulness of the trifluoroacetyl radical on the amino group is noted both with regard to its strong directing influence and the great ease with which it is removed. The first triamino- and tetraminofluorene are described.

In studying various series of fluorene compounds, especially ring-fluorinated *N*-2-fluorenylacetamides, we have found that hitherto unreported nitrations of some derivatives of 2-fluorenamine are extremely useful in giving substances with certain desired positions substituted or blocked. Reduction of this nitro group and further nitration, followed by a deamination at the first position of nitration, has given us high over-all yields of some disubstituted fluorenes by the best route available.

Like *N*-2-fluorenylperfluorobutyramide,[3] *N*-2-fluorenyltrifluoroacetamide can be nitrated in the 7- position. The yields approach 90%. *N*-2-Fluorenylacetamide on the other hand gives a mixture of the 3- and 7-nitro derivatives.[3–5] The 7-nitro derivative is obtained from the latter reaction in low yield following a time-consuming separation.[3,4] The trifluoroacetyl group is additionally useful because of ready cleavage. A few minutes in hot dilute alkali leads to almost quantitative recovery of high quality 7-nitro-2-fluorenamine. Anyone who has tried the customary dinitration of fluorene, separation of isomers, and monoreduction of 2,7-dinitrofluorene, will appreciate over-all yields of 75 to 80% from 2-fluorenamine in three easy steps, all conveniently carried out in a beaker or Erlenmeyer flask (one-mole level customarily). *N*-2-(7-nitrofluorenyl)trifluoroacetamide can be reduced with Raney nickel and hydrazine hydrate[6] (0.05 mole, 90%), and the resulting amine acetylated and hydrolyzed in hot alkali to give the known 2-acetamido-7-aminofluorene. The latter is also equally conveniently obtained from 2-amino-7-nitrofluorene by acetylation and reduction[6] (0.05 mole, 90%).

Nitration of *N*-2-(7-nitrofluorenyl)trifluoroacetamide, of *N*-2-(3-nitrofluorenyl)trifluoroacetamide and dinitration of *N*-2-(fluorenyl)trifluoroacetamide all gave 80 to 90% yields of *N*-2-(3,7-dinitrofluorenyl)trifluoroacetamide which was readily hydrolyzed to the known 2-amino-3,7-dinitrofluorene, identical with the hydrolysis product of *N*-2-(3,7-dinitrofluorenyl)acetamide.[7]

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(1) This work was supported in part by research grant C-1744 from the National Cancer Institute of the U. S. Public Health Service. The preceding paper in this series is T. L. Fletcher, W. H. Wetzel, M. J. Namkung, and H. L. Pan, *J. Am. Chem. Soc.*, **81**, 1092 (1959).

(2) To whom communications regarding this manuscript should be addressed.

(3) E. Sawicki, B. Chastain, and H. Bryant, *J. Org. Chem.*, 21, 754 (1958).

(4) *N*-2-(9-Oxofluorenyl)acetamide gives a 90% yield of the 3-nitro derivative [N. Ishikawa and M. Hayashi, *Yûki Gôsei Kagaku Kyôkai Shi*, **15**, 405 (1957)]. For certain 2,3- or 3-substituted fluorenones (*e.g.* 2,3-diamino- or 3-amino-) which can be reduced to fluorenes in high yield, nitration of *N*-2-(9-oxofluorenyl)acetamide is to be preferred as an approach.

(5) *N*-2-Fluorenyl-*p*-toluenesulfonamide gives high yields of the 3-nitro isomer but hydrolysis of the tosyl group is troublesome [N. Ishikawa and M. Hayashi, *Yûki Gôsei Kagaku Kyôkai Shi*, **15**, 202 (1957)].

(6) T. L. Fletcher and M. J. Namkung, *J. Org. Chem.*, **23**, 680 (1958). Footnote[d] in the table of this reference erroneously gives the melting point of the analytical sample of *N*-2-(7-nitrofluorenyl)trifluoroacetamide as 201–201.5°; this should read 248.5–249.5°.

Whereas it was reported[8] that *N*-2-(1,3,7-trinitrofluorenyl)-*p*-toluenesulfonamide was obtained by nitration of 2-*p*-tosylamidofluorene, the same procedure gave us 45 to 50% yields of *N*-2-(3,7-dinitrofluorenyl)-*p*-toluenesulfonamide. The latter was also obtained by nitration of *N*-2-(7-nitrofluorenyl)-*p*-toluenesulfonamide and of *N*-2-(3-nitrofluorenyl)-*p*-toluenesulfonamide.[5,8]

Reduction[6] of 2-acetamido-3,7-dinitrofluorene gave 2-acetamido-3,7-fluorenediamine and of 2-amino-3,7-dinitrofluorene gave us the first fluorenetriamine[9] to be reported.

Nitration[10] of 2,7-diacetamidofluorene gave the 3,6-dinitro derivative which we reduced[6] to the corresponding diamine. Hydrolysis of the diacetamidodinitro compound gave 2,7-diamino-3,6-dinitrofluorene which was reduced[6] to the first reported tetraminofluorene.

We repeated the interesting nitration of 2-*N*,*N*-dimethylaminofluorene[8] with sodium nitrite in cold acetic acid. These workers reported that their analytical sample melted at 100–103°. Before further work with this compound, we attempted to narrow the melting range by repeated crystallization from alcohol and raised this to 102.5–105.5° (corr.), but crops from the filtrates melted up to 120°. Samples melting at each range were analytically pure. We then found that recrystallization from ligroin, by the technique described below, gave us blocks and needles, melting at 107–108° and 125–126.5°, respectively, both of which were analytically identical. Reduction[6] of the lower melting isomer to the amine followed by dimethylation with trimethyl phosphate[11] gave 2,3-*N*,*N*,*N*′,*N*′-tetramethylfluorenediamine identical with the product of tetramethylation of authentic 2,3-diaminofluorene. The 3-*N*-acetyl and 3-*N*-benzylidene derivatives of the 3-amino compound were also prepared. The same reactions were carried out on the other isomer giving 2-*N*,*N*-dimethylamino-*x*-aminofluorene and the corresponding tetramethylated diamine.

Nitration of each nitrodimethylaminofluorene gave the same compound, 3,*x*-dinitro-2-(*N*-methyl-*N*-nitroso)fluorenamine, which was reported by Bell and Mulholland[8] as the 3,1-dinitro compound, from a more drastic nitration of 2-*N*,*N*-dimethylfluorenamine.

Since there appeared to be no direct confirmation that the higher melting isomer was the 1-nitro compound, we synthesized 1,2-fluorenediamine, a new compound. When the diamine was treated with an excess of trimethyl phosphate,[11] the 1,2-*N*,*N*,*N*′,*N*′-tetramethyldiamine was produced, identical with the tetramethyl compound above.

2-*N*-*N*-Dimethyl-9-oxofluorenamine was nitrated in a similar manner[8] to give deeply purple colored 2-*N*,*N*-dimethyl-3-nitro-9-oxofluorenamine. No isomer was detected, although there was one (possibly two) yellow by-product in small yield. The main product was identical with the compound resulting from oxidation of 2-*N*,*N*-dimethylamino-3-nitrofluorene, an oxidation effected by anil formation with *o*-nitrosotoluene, and hydrolysis.[12]

Reduction of 2-*N*,*N*-dimethyl-3-nitro-9-oxofluorenamine with sodium borohydride[13] led to the 9-ol, which was reduced[6] to 2-*N*,*N*-dimethyl, 3-(9-hydroxyfluorene)diamine.

## EXPERIMENTAL[14]

*N-2-(7-Nitrofluorenyl)trifluoroacetamide.* To a suspension of 55.4 g. (0.2 mole) of *N*-2-fluorenyltrifluoroacetamide in 800 ml. of glacial acetic acid at 45°, 40 ml. of nitric acid (*d.*, 1.42) and 6 ml. of concd. sulfuric acid were added with stirring. When the mixture was heated to 55°, an exothermic reaction took place with a rise in temperature to 60° and formation of a mass of yellow needles. The stirring was continued for 10 min. and the reaction mixture was allowed to cool to room temperature. The precipitate was filtered, washed with 50 ml. of cold glacial acetic acid and with water, and dried, giving 53.5 g. (83.5%), m.p. 245–247°. One recrystallization from acetone (Darco) gave the pure product, m.p. 248.5–249.5°.[6]

*N-2-(7-Acetamidofluorenyl)trifluoroacetamide.* The preceding compound was reduced[6] and the amine acetylated in pyridine (30 min., steam bath). The product was stirred into water and the mixture acidified with hydrochloric acid. After filtration and drying a quantitative crude yield was obtained m.p. 315–318° (corr.) (capillary in an aluminum block). Two recrystallizations from alcohol gave an analytical sample, m.p. 323–324° (corr.), with slight discoloration at 322°.

*Anal.* Calcd. for $C_{17}H_{13}F_3N_2O_2$: C, 61.08; H, 3.92; N, 8.38. Found: C, 60.92; H, 3.80; N, 8.40.

*Hydrolysis of N-2-(7-nitrofluorenyl)trifluoroacetamide.* A suspension of 53.5 g. of the amide in 1 l. of alcohol was brought to a boil and 1 l. of boiling 1% aqueous sodium hydroxide was added. All the solids dissolved, but in a few minutes a dark red precipitate formed. After a few more minutes of boiling, the mixture was cooled and 2 l. of water was added. Upon filtration and drying, 37 g. (quantitative) was recovered, m.p. 228–232°. One recrystallization from acetone gave 25.7 g., m.p. 234–235° in the first crop. Another 9.2 g., m.p. 232–234° was obtained in further crops. The reported melting point of 2-nitro-7-fluorenamine is 232°.[15]

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(7) N. Ishikawa and M. Hayashi, *Yûki Gôsei Kagaku Kyôkai Shi*, **14**, 80 (1956), reported 2-acetamido-3,7-dinitrofluorene, m.p. 270–272° dec.; our analytical sample melted at 280–281° dec. These workers reported that 2-amino-3,7-dinitrofluorene melted at 280–282° dec., whereas our analytically pure sample melted at 275–276° dec.

(8) F. Bell and D. B. Mulholland, *J. Chem. Soc.*, 2020 (1949).

(9) Reduction of 2,4,7-trinitrofluorenone [J. Schmidt and K. Bauer, *Ber.*, **38**, 3758 (1905)] gave 2,4,7-triamino-triaminofluoren-9-ol (as hydrochloride).

(10) A. Barker and C. C. Barker, *J. Chem. Soc.*, 870 (1954).

(11) T. L. Fletcher, M. E. Taylor, and A. W. Dahl, *J. Org. Chem.*, **20**, 1021 (1955).

(12) This is similar to the method using *p*-nitrosodimethylaniline [G. M. Bennett and E. V. Bell, *Org. Syntheses*, **Coll. Vol. II**, 223 (1943)].

(13) H. L. Pan and T. L. Fletcher, *J. Org. Chem.*, **23**, 799 (1958).

(14) Melting points were taken on a Fisher-Johns apparatus and are corrected to standards. Microanalyses were done by Schwarzkopf Microanalytical Laboratory, Woodside, N. Y.

(15) O. Diels, E. Schell, and S. Tolson, *Ber.*, **35**, 3284 (1902).

*Hydrolysis of N-2-(7-acetamidofluorenyl)trifluoroacetamide.* This compound was hydrolyzed in a similar manner to give the known *N*-monoacetyl-2,7-fluorenediamine.[6]

*Trifluoroacetylation of 3-nitro-2-fluorenamine.* To a solution of 1 g. of 3-nitro-2-fluorenamine in 100 ml. of benzene, 0.5 ml. of trifluoroacetic anhydride was added drop by drop. The mixture was heated on the steam bath for 1 hr., boiled down to small volume, and cooled. The yellow precipitate, filtered and dried, gave 1.2 g. (83.5%), m.p. 182–182.5°. Recrystallization from alcohol gave an analytical sample, m.p. 182–182.5°.

*Anal.* Calcd. for $C_{15}H_9F_3N_2O_3$: C, 55.91; H, 2.82; N, 8.69. Found: C, 56.06; H, 2.72; N, 8.59.

*N-2-(3,7-Dinitrofluorenyl)trifluoroacetamide.* (*a*) *Nitration of N-2-(7-nitrofluorenyl)trifluoroacetamide.* To a mixture of 30 ml. each of fuming nitric acid (*d.*, 1.5) and glacial acetic acid at 30°, 6.5 g. (0.02 mole) of the above was added in small portions with stirring. After warming to 60°, the mixture was removed from the heat. Stirring was continued and the temperature rose to a maximum of 70°. After cooling to room temperature, the pale yellow precipitate was filtered, washed with water, and dried, giving 6.6 g. (90%), m.p. 250–255°. Recrystallization from acetic acid (Darco) and from toluene gave a sample, m.p. 256–258° dec., slight discoloration at 255°.

(*b*) *Nitration of N-2-(3-nitrofluorenyl)trifluoroacetamide.* The 3-nitro isomer was nitrated in the same way to give a substance identical with the above melting point and mixture melting point.

(*c*) *Dinitration of N-2-(fluorenyl)trifluoroacetamide.* To a mixture of 40 ml. each of fuming nitric acid (*d.*, 1.5) and glacial acetic acid at 30°, 5.6 g. (0.02 mole) of *N*-2-fluorenyltrifluoroacetamide was added in small portions with stirring. The mixture was heated to 65° and removed from the heat. The temperature of the mixture rose to 70° and then gradually dropped to room temperature. The pale yellow product was filtered off, washed with water, and dried, giving 6.3 g. (86%), m.p. 250–255° dec. with discoloration at 215°. Recrystallization from acetic acid (Darco) and from toluene gave an analytical sample, m.p. 257–258° dec. and with discoloration at 255°. The mixture melting point with the two nitration products above were undepressed.

*Anal.* Calcd. for $C_{15}H_8F_3N_3O_5$: C, 49.05; H, 2.19; N, 11.44. Found: C, 49.24; H, 2.07; N, 11.40.

*N-2-(3,7-Dinitrofluorenyl)acetamide.* To a mixture of 200 ml. each of fuming nitric acid (*d.*, 1.5) and glacial acetic acid, 22.3 g. (0.1 mole) of *N*-2-fluorenylacetamide was added in small portions at room temperature. The mixture was heated to 55° and allowed to stand overnight. The precipitate was filtered, washed with water and then alcohol, and dried, giving 23.5 g. (75%), m.p. 275–280° dec. One recrystallization from toluene (Darco) gave an analytical sample, m.p. 280–281° dec.,[7] discoloration at 277°.

*Anal.* Calcd. for $C_{15}H_{11}N_3O_5$: C, 57.51; H, 3.54; N, 13.42. Found: C, 57.60; H, 3.49; N, 13.20.

*3,7-Dinitro-2-fluorenamine.* (*a*) *Hydrolysis of trifluoroacetyl derivative.* To a solution of 2 g. of *N*-2-(3,7-dinitrofluorenyl)trifluoroacetamide in 300 ml. of alcohol and 30 ml. of acetone, 25 ml. of 1% aqueous sodium hydroxide was added and the mixture was boiled down to 200 ml. The red precipitate was filtered, washed with acetone and dried, yielding 1.3 g. (88%), m.p. 270–274° dec. One crystallization from acetone raised the melting point to 275–276° dec.[7]

(*b*) *Hydrolysis of the acetyl derivative.* A mixture of 5 g. of *N*-2-(3,7-dinitrofluorenyl)acetamide, 500 ml. of acetone and 100 ml. of concd. hydrochloric acid was refluxed for 20 hr. as the solution turned dark and red needles formed. The solution was boiled down to 250 ml. and cooled. Filtration was followed by washing with dilute ammonium hydroxide. The dried material weighed 4.0 g. (93%), m.p. 272–276° dec. One recrystallization from acetone gave an analytical sample, m.p. 275–276° dec.[7] A mixture melting point with the preceding hydrolysis product showed no depression.

*Anal.* Calcd. for $C_{13}H_9N_3O_4$: C, 57.56; H, 3.34; N, 15.49. Found: C, 57.71; H, 3.34; N, 15.60.

*N-2-(3,7-Dinitrofluorenyl)-p-toluenesulfonamide.* (a) To a mixture of 20 ml. of fuming nitric acid (*d.*, 1.5) and 20 ml. of glacial acetic acid, 3.35 g. (0.01 mole) of *N*-2-fluorenyl-*p*-toluenesulfonamide was added gradually during 10 min. with stirring and cooling to 20°. The reaction mixture was then poured into water, and the precipitate filtered, washed with a little cold acetic acid followed by 50 ml. of alcohol, and dried, giving 4.2 g. of crude product. One recrystallization from acetone (Darco) gave 2.2 g. (52%) of the dinitro compound, m.p. 226–228°. Two further recrystallizations gave an analytical sample, m.p. 232.5–233.5°.

*Anal.* Calcd. for $C_{20}H_{15}N_3O_6S$: C, 56.46; H, 3.55; N, 9.88. Found: C, 56.54; H, 3.80; N, 9.65.

(b) To a nitrating mixture identical with the preceding, 3.81 g. (0.01 mole) of *N*-2-(7-nitrofluorenyl)-*p*-toluenesulfonamide was added gradually at 10–20°; the precipitate was worked up as before giving 2.2 g. (52%), m.p. 219–221°. One crystallization from acetone (Darco) gave 1.8 g., m.p. 232–232.5°.

(c) The same procedure with *N*-2-(3-nitrofluorenyl)-*p*-toluenesulfonamide gave 1.9 g. of product, m.p. 232–233°. Mixture melting points of this with each of the two preceding substances were undepressed.

*N-2-(3,7-Diaminofluorenyl)acetamide.* To a suspension of 1 g. of *N*-2-(3,7-dinitrofluorenyl)acetamide in a boiling mixture of 500 ml. of toluene and 200 ml. of alcohol, a small amount of Raney nickel and 2 ml. of 100% hydrazine hydrate were added.[6] The solid material dissolved gradually while the reaction mixture boiled down to 200 ml. at which point a white precipitate formed. Alcohol (200 ml.) was added to effect solution, and the boiling was continued (to 200 ml.) until no alkaline vapors were detected. The nickel was filtered off and the filtrate boiled down to 50 ml. and cooled. A white precipitate was filtered off and dried, giving 0.75 g. (82.5%), m.p. 262–265°. One recrystallization from methanol gave an analytical sample, m.p. 269–270°.

*Anal.* Calcd. for $C_{15}H_{15}N_3O$: C, 71.12; H, 5.97; N, 16.59. Found: C, 70.91; H, 6.09; N, 16.40.

*2,3,7-Triaminofluorene.* Reduction[6] in the usual manner of 1 g. of 3,7-dinitro-2-fluorenamine gave us 0.7 g. (90%) of the triamino compound, m.p. 224–227°. Two recrystallizations from alcohol gave an analytical sample, m.p. 230–232° (softening at 229°).

*Anal.* Calcd. for $C_{13}H_{13}N_3$: C, 73.90; H, 6.20; N, 19.89. Found: C, 73.99; H, 6.35; N, 20.05.

*2,7-Diacetamido-3,6-fluorenediamine.* To a suspension of 2 g. of 2,7-diacetamido-3,6-dinitrofluorene in 500 ml. of boiling alcohol, 4 ml. of 100% hydrazine hydrate, and a small amount of Raney nickel were added.[6] After 5 min., 4 ml. of 100% hydrazine hydrate and Raney nickel were again added and this was repeated three more times. A yield of 1.4 g. (84%) was obtained which decomposed slowly above 400° (capillary tube in aluminum block). One recrystallization from dimethylformamide gave an analytical sample which decomposed slowly above 400°.

*Anal.* Calcd. for $C_{17}H_{18}N_4O_2$: C, 65.79; H, 5.85; N, 18.05. Found: C, 65.91; H, 5.86; N, 18.07.

*3,6-Dinitro-2,7-fluorenediamine.* A solution of 2 g. of 2,7-diacetamido-3,6-dinitrofluorene in 8 ml. of concd. sulfuric acid and 2 ml. of water was heated on a steam bath for 40 min. The reaction mixture was cooled, poured into 100 ml. of water, and neutralized with aqueous sodium hydroxide. The dark purple precipitate was filtered, washed with water, and dried, giving 1.5 g. (96%). One recrystallization from nitrobenzene gave an analytical sample, m.p. 335° (vigorous decomposition), in a capillary in an aluminum block.

*Anal.* Calcd. for $C_{13}H_{10}N_4O_4$: N, 19.58. Found: N, 19.31.

*2,3,6,7-Tetraminofluorene.* The foregoing compound (0.7 g.) was reduced[6] to give 0.5 g. (90%), m.p. 259–262°. Two recrystallizations from alcohol raised the melting point to 265–267°, with some softening and discoloration ~260°.

*Anal.* Calcd. $C_{13}H_{14}N_4$: C, 69.00; H, 6.24; N, 24.76. Found: C, 68.92; H, 6.54; N, 24.44.

*Nitration of 2-N,N-dimethylaminofluorene,*[8] *and separation of isomers.* To a magnetically stirred solution of 104.5 g. (0.5 mole) of 2-*N*,*N*-dimethylaminofluorene in 1 l. of glacial acetic acid, a solution of 57 g. (0.83 mole) of sodium nitrite in 330 ml. of water was added gradually over a period of 15 min. (ice-water bath). The solution first turned green, then a brick-red color and a red precipitate formed. The temperature was kept at 14–16° and the reaction mixture stirred for 10 more min. after addition of the sodium nitrite. After 30 min. in the ice-water bath, the precipitate was filtered, washed with 50 ml. of cold acetic acid and then water, and dried, giving 116 g. (91%), m.p. 97–105°. Recrystallization from alcohol (1 l.) gave 106 g. in the first crop, m.p. 100–107°, and 4.4 g. in the second and third crops, m.p. 95–108°.

The mixture (106 g.) was boiled with 2.5 l. of ligroin (*d.*, 0.67–0.69) and the residue was separated by decantation. Upon cooling, two sets of crystals, blocks, and needles formed. The decantate was then warmed, the needle-like crystals dissolved, and separation was again effected by decantation. The two residues from ligroin were combined and recrystallized from 1.4 l. of ligroin (*d.*, 0.72–0.74), giving 60.8 g. (47.7%), m.p. 107–108°. The decanted solution was cooled to form both types of crystals. The mixture was heated again to dissolve the needles, decanted, and the residue recrystallized from ligroin three times (300 ml. each) to yield another 11.2 g., m.p. 106–108°. From the filtrates, 1.7 g. were recovered, m.p. 112–119°, which was combined with further like crops. The decanted solution was boiled down to 1.2 l. and cooled, and the process continued, aided by the easy mechanical separation of the large blocklike crystals. A further 8.5 g., m.p. 106–109°, was isolated in this way, and 21.0 g. of needles, m.p. 112–119°.

All of the crude higher-melting isomer (22.7 g.) was combined and recrystallized from methanol giving 17.8 g. (14.0%) in the first crop, m.p. 125–126.5°, and 2.8 g. (2.2%) in the second crop, m.p. 119–123°. Another recrystallization of the first crop from methanol gave an analytical sample, m.p. 125.5–126.5°.

*Anal.* Calcd. for $C_{15}H_{14}N_2O_4$: N, 11.02. Found: N, 10.98.

All of the 3-nitro- (lower-melting) isomer (81.2 g.) was combined and recrystallized from methanol, giving 71 g. (56.0%), m.p. 107.5–108.5°.

*Anal.* Calcd. for $C_{15}H_{14}N_2O_2$: C, 70.85; H, 5.55; N, 11.02. Found: C, 70.75; H, 5.66; N, 10.80.

*Nitration of 2-N,N-dimethylamino-x(-1-)-nitro-fluorene (to 1,3-dinitro-2-(N-methyl-N-nitroso)fluorenamine).* To a solution of 2.54 g. (0.01 mole) of 2-*N*,*N*-dimethylamino-1-nitrofluorene in 50 ml. of warm (50°) glacial acetic acid, 2 ml. of nitric acid (*d.*, 1.42) was added with stirring. The mixture was heated to 75° and allowed to cool. A yellow precipitate was filtered, washed with water, and dried, giving 2.5 g. (80%), m.p. 161–164°. Two recrystallizations from alcohol (the first with Darco) gave an analytical sample, m.p. 166–167°.[16]

*Anal.* Calcd. for $C_{14}H_{10}N_4O_5$: C, 53.51; H, 3.21; N, 17.83. Found: C, 53.59; H, 3.25; N, 17.98.

*Nitration of 2-N,N-dimethylamino-3-nitrofluorene.* This was performed in the same way as the preceding experiment. The recrystallized product (crude, 88%, m.p. 165–166°) melted at 165–166.5°. The mixture melting point with the above was undepressed.[16]

The 3- and the 1-mononitro compounds were each reduced in the usual way with Raney nickel and hydrazine hydrate[6] to give, respectively, *2-dimethylamino-3-aminofluorene* (85–90%), m.p. 155–156° (analysis reported previously[6]), and *2-dimethylamino-1-aminofluorene* (85–90%), m.p. 151.5–152°.

*Anal.* Calcd. for $C_{15}H_{16}N_2$: N, 12.49. Found: N, 12.69.

*2,3-N,N,N',N'-Tetramethyldiaminofluorene.* (a) In a 50-ml. pear-shaped flask, equipped with a reflux condenser and a mechanical stirrer through the condenser, 1.0 g. (0.0051 mole) of 2,3-fluorenediamine[6] and 2 g. (0.014 mole) of trimethylphosphate were combined and the mixture heated at 183° ± 2° in an oil bath for 1 hr. Sodium hydroxide (10 ml., 10% aqueous) was added and the mixture boiled for 5 min. and poured into 100 ml. of cold water. The precipitate was filtered and dried, giving 0.6 g. (47%), m.p. 99–102°. One recrystallization from alcohol gave a pure product, m.p. 101.5–102.5°.

(b) 2-Dimethylamino-3-aminofluorene (3.92 g., 0.0175 mole) and 5.6 g. (0.04 mole) of trimethyl phosphate were treated in a similar manner to yield 99% of a crude product, m.p. 90–97°. Crystallization from ethanol and then methanol gave material, m.p. 101–101.5°. The mixture melting point with the product from (a) was undepressed.

*Anal.* Calcd. for $C_{17}H_{20}N_2$: C, 80.91; H, 7.99; N, 11.10. Found: C, 80.97; H, 8.02; N, 11.10.

*N-3-(2-N',N'-Dimethylaminofluorenyl)acetamide.* 2-Dimethylamino-3-aminofluorene was acetylated to give a product, m.p. 232–233°.

*Anal.* Calcd. for $C_{17}H_{18}N_2O$: N, 10.52. Found: N, 10.72.

*3-N-Benzylidene-(2-N',N'-dimethylamino)fluorenamine.* To a boiling solution of 1.12 g. (0.005 mole) of 2-dimethylamino-3-aminofluorene in 50 ml. of alcohol, 0.53 g. (0.005 mole) of benzaldehyde was added and the mixture was boiled down to 10 ml. (20 min.). After cooling to room temperature, the yellow precipitate was filtered off and dried, giving 1.45 g. (93%), m.p. 128.5–129.5°. One recrystallization from ligroin (*d.*, 0.67–0.69) gave an analytical sample, m.p. 128.5–129.5°.

*Anal.* Calcd. for $C_{22}H_{20}N_2$: C, 84.58; H, 6.45; N, 8.97. Found: C, 84.68; H, 6.40; N, 8.84.

*2,1-N,N,N',N'-Tetramethyldiaminofluorene.* (a) 2-Dimethylamino-1-aminofluorene (2.24 g.) was methylated by the procedure given above, giving 2 g. (80%), m.p. 62–64°. Three recrystallizations from methanol gave an analytical sample, m.p. 66.5–67°.

*Anal.* Calcd. for $C_{17}H_{20}N_2$: C, 80.91; H, 7.99; N, 11.10. Found: C, 81.03; H, 8.12; N, 11.22.

(b) A mixture of 0.8 g. of 1,2-diaminofluorenone,[17] 0.6 g. of sodium hydroxide, 10 ml. of diethylene glycol, and 0.6 ml. of 85% hydrazine hydrate was refluxed for 3 hr., then the mixture was boiled without a condenser until the boiling point of the mixture rose to 205°, and refluxed for 2 more hr. The reaction mixture was cooled and poured into 50 ml. of water. The grayish white precipitate was filtered, washed with water, and dried, giving 0.6 g. (80%) m.p. 162–180°. This was extracted with ligroin (*d.*, 0.67–0.69) and the ligroin evaporated to dryness. The residue was recrystallized twice from benzene giving *1,2-diaminofluorene,* m.p. 182–183° which was tetramethylated in the same way as the 2,3-isomer giving a product (two recrystallizations from benzene) melting at 65–66°. A mixture melting point with the product from (a) was undepressed.

*2-N,N-Dimethylamino-3-nitro-9-oxofluorene.* (a) A solution of 32 g. (0.046 mole) of sodium nitrite in 80 ml. of water was added dropwise with stirring to 10 g. of 2-*N*,*N*-dimethylaminofluorenone in 600 ml. of glacial acetic acid at room temperature. The temperature rose slightly. Stirring was then continued for 30 min. The precipitate was filtered, washed with water, and dried, giving deep purple crystals, 6.8 g. (56.5%), m.p. 165.5–167°.

By dilution of the filtrate with water, a yellow precipitate was obtained (5 g.), m.p. 130–140°, which was recrystallized from carbon tetrachloride twice, to give 0.7 g., m.p. 174.5–176°, which has not been characterized further. The second crop from the first crystallization (3.1 g.) melted from 128–135° and has not been purified further.

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[16] Bell and Mulholland[8] by further nitration of their crude reaction mixture isolated 1,3-dinitro-2-(*N*-methyl-*N*-nitroso)fluorenamine, m.p. 165° dec.

[17] J. W. Cook and J. S. Moffat, *J. Chem. Soc.*, 1160 (1950).

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.

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

# Preparation of ω-Aminoalkyl Secondary Nitramines

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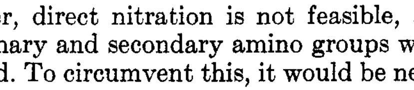
A method was developed for selectively converting secondary amines to the corresponding nitramines in the presence of primary amino groups. The method consists of three steps: (1) complete acetylation of the amino groups, (2) selective nitrolysis of the amido group by treatment of the acetylated amine 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:

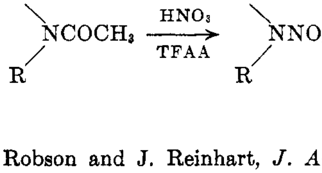


$$R\overset{H}{\overset{|}{N}}CH_2CH_2NH_2 \longrightarrow R\overset{NO_2}{\overset{|}{N}}CH_2CH_2NH_2$$

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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(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).