TABLE II
PROTON MAGNETIC RESONANCE DATA[a]

Adduct	Chemical shifts, δ (ppm) Alkyl H	Isolated $-CH_2-$	Methine H	Other	Rel intensities
I	0.8–2.2 (m)	2.4–3.1 (m)	4.4 (m)		9:2:1
II	1.2–2.6 (m)	2.6–3.4 (m)		$CBrCH_3$, 1.0 (3), $J_{HH} = 6.5$	7:2:3
II[b]	0.7–3.2 (m)			CH=C, 5.0–5.8 (m)	10:1
III	0.7–2.2 (m)		4.5 (m) 2.4–3.5 (m)		13:1:1
IV	1.2–3.3 (m)		4.1–5.1 (m)		9:1
VII	1.2 (3), $J_{HH} = 7.0$		4.4 (m)	All CH_2, 2.2–4.0 (m)	3:1:6
IX				All H, 3.0–4.7 (m)	
XI	0.8–2.5 (m)		6.5 (2), $J_{HH} = 1.0$ 3.2 (m)		7:1:1
XII	2.8 (1) 1.9 (2), $J_{HH} = 6.5$		3.6 (4), $J_{HH} = 6.5$		3:3:1
XIV	0.7–3.4 (m)			CH=C, 6.4 (2 of 2), $J_{HH} = 4.5$, $J_{HF} = 13.5$ CH=C, 5.6 (4), $J_{HH} = 5.5$	9:1:1

[a] In parentheses is given the multiplicity of the peak; the coupling constants are in cps. [b] Olefinic product.

$CH(CH_2)_4CH_3$. *Anal.* Calcd for $C_{10}H_{15}BrClF_3$: C, 39.1; H, 4.89. Found: C, 39.2; H, 5.23. Both the ir and the pmr spectra (with a very broad signal, δ 5.5–6.3, for the two vinyl protons) were consistent with the above structure.

Dehydrohalogenation of $CCl_3CH_2CHBrCH_2Cl$ (X).—The attempted dehydohalogenation of X gave a mixture of products, none of which were identified. This complex product mixture was similar to that obtained from the attempted dehydrohalogenation of $CHClBrCH_2CHBr(CH_2)_5CH_3$ described previously.[5]

Dehydrohalogenation of $CHBr_2CH(CCl_3)CH_2CH_2CH_3$ (XII).—The attempted dehydrohalogenation of XII, similar to the reaction of X, gave a mixture of products, none of which was identified.

Dehalogenation of $CF_2BrCFClCH_2CHBr(CH_2)_3CH_3$ (II).—Compound II (113 g) in isopropyl alcohol (50 ml) was added slowly to a slurry of granulated zinc (22.7 g) in isopropyl alcohol (100 ml) at 100°. After refluxing for 4 hrs the reaction mixture was poured into water and the organic layer was separated, washed, and dried. Distillation gave 47.3 g of product, bp 68–69° (10 mm), identified as $CF_2{=}CFCH_2CHBr(CH_2)_3CH_3$. *Anal.* Calcd for $C_8H_{12}BrF_3$: C, 39.2; H, 4.9. Found: C, 38.8; H, 4.91. The pmr and ir spectra were consistent with the above structure.

Dehalogenation of $CCl_3CH_2CHBrCH_2Cl$ (X).—Surprisingly, the attempted dehalogenation of X gave no identifiable product. However, only 40% of the starting material was recovered after the reaction.

Dehalogenation of $CHBr_2CH(CCl_3)CH_2CH_2CH_3$ (XI).—The attempted dehalogenation of XI gave no reaction and the starting material was recovered unchanged.

Registry No.—Copper chloride, 7758-89-6; ethanolamine, 141-43-5; $CH_3CH{=}C(CFClCF_2Br)CH_2(CH_2)_3CH_3$, 30428-57-0; $CH_3C(CFClCF_3Br){=}CH(CH_2)_4CH_3$, 30428-58-1; $CF_2{=}CFCH_2CHBr(CH_2)_3CH_3$, 30428-59-2; $CF_2BrCFClCH{=}CH(CH_2)_3CH_3$ 30428-56-9.

Mannich Reactions of 2-Fluoro-2,2-dinitroethanol[1]

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2-Fluoro-2,2-dinitroethanol undergoes the Mannich reaction with primary and secondary amines to give the corresponding 2-fluoro-2,2-dinitroethylamines. In one example (allylamine), forcing conditions were used to obtain the corresponding bis(2-fluoro-2,2-dinitroethyl)amine. Hydrazine gave *N,N'*-bis(2-fluoro-2,2-dinitroethyl)hydrazine. Ammonia gave 2-fluoro-2,2-dinitroethylamine which reacted with chloroformates to give *N*-fluorodinitroethylcarbamates.

β,β-Dinitro alcohols undergo the Mannich reaction with a variety of amines to give β,β-dinitroalkylamines.[2] Published examples of the Mannich reaction of 2-fluoro-2,2-dinitroethanol are limited to ammonia[3,4] and to $NH_2C(CH_2OAc)_3$.[5] Ammonia yielded 2-fluoro-2,2-dinitroethylamine[3] or bis(2-fluoro-2,2-dinitroethyl)amine,[3,4] depending on the reaction conditions, whereas $NH_2C(CH_2OAc)_3$ gave the 1:1 condensation product. The present study explores the scope of the Mannich reaction of 2-fluoro-2,2-dinitroethanol.

The reactions of a variety of primary and secondary amines with 2-fluoro-2,2-dinitroethanol are summarized in Table I. In aqueous solution at low temperatures, high yields of 1:1 condensation products were formed, and other functional groups, such as carboxy, acetal, and hydroxy groups, did not interfere. The condensa-

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[2] For a review see P. Noble, Jr., F. G. Borgardt, and W. L. Reed, *Chem. Rev.*, **64**, 32 (1964).

[3] H. G. Adolph and M. J. Kamlet, *J. Org. Chem.*, **34**, 45 (1969).

[4] R. G. Gafurov, S. I. Sviridov, F. Ya. Natsibullin, and L. T. Eremenko, *Izv. Akad. Nauk SSSR, Ser. Khim.*, 383 (1970).

[5] D. A. Nesterenko, O. M. Savchenko, and L. T. Eremenko, *ibid.*, 1100 (1970).

TABLE I

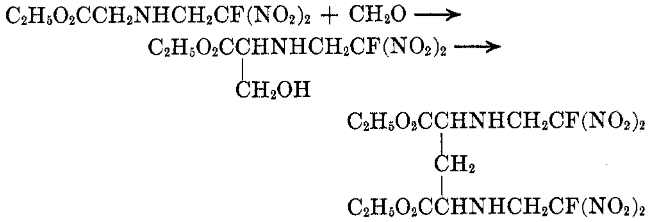
REACTION OF 2-FLUORO-2,2-DINITROETHANOL WITH AMINES

Starting material	Product	Yield, %
CH_3NH_2	$CH_3NHCH_2CF(NO_2)_2$	72
$(CH_3)_2NH$	$(CH_3)_2NCH_2CF(NO_2)_2$	78
$HO_2CCH_2NH_2$	$HO_2CCH_2NHCH_2CF(NO_2)_2$	64
$C_2H_5O_2CCH_2NH_2$	$C_2H_5O_2CCH_2NHCH_2CF(NO_2)_2$	97
$(C_2H_5O)_2CHCH_2NH_2$	$(C_2H_5O)_2CHCH_2NHCH_2CF(NO_2)_2$	94
$HO_2CCH_2CH(CO_2H)NH_2$	$HO_2CCH_2CH(CO_2H)NHCH_2CF(NO_2)_2$	78
$HOCH_2CH_2NH_2$	$HOCH_2CH_2NHCH_2CF(NO_2)_2$	74
$CH_2{=}CHCH_2NH_2$	$CH_2{=}CHCH_2NHCH_2CF(NO_2)_2$	75–93
$CH_2{=}CHCH_2NHCH_2CF(NO_2)_2$	$CH_2{=}CHCH_2N[CH_2CF(NO_2)_2]_2$	49

tion also takes place in organic solvents; allylamine gave a 93% yield of *N*-(2-fluoro-2,2-dinitroethyl)allylamine when methylene chloride was used as the solvent.

More forcing conditions yielded the 2:1 condensation product of allylamine. Thus, when a neat mixture of 2-fluoro-2,2-dinitroethanol and the 1:1 condensation product, *N*-(2-fluoro-2,2-dinitroethyl)allylamine, was heated for 6 hr at 90–95°, a 49% yield of *N*,*N*-bis(2-fluoro-2,2-dinitroethyl)allylamine was isolated.

An attempt was also made to prepare a 2:1 product of glycine ethyl ester under forcing conditions (115–120°). The product, however, was identified as *N*,*N′*-bis(2-fluoro-2,2-dinitroethyl)-*N*,*N′*-bis(carbethoxymethyl)methylenediamine. Formaldehyde, liberated by the decomposition of 2-fluoro-2,2-dinitroethanol, apparently condenses with the active methylene group of the 1:1 adduct as follows.



$$C_2H_5O_2CCH_2NHCH_2CF(NO_2)_2 + CH_2O \longrightarrow \underset{\displaystyle CH_2OH}{C_2H_5O_2C\overset{|}{C}HNHCH_2CF(NO_2)_2} \longrightarrow \begin{array}{l} C_2H_5O_2CCHNHCH_2CF(NO_2)_2 \\ \quad\;\; | \\ \quad\; CH_2 \\ \quad\;\; | \\ C_2H_5O_2CCHNHCH_2CF(NO_2)_2 \end{array}$$

The Mannich reaction of 2,2-dinitropropanol with hydrazine has been reported to give *N*,*N′*-bis(2,2-dinitropropyl)hydrazine.[6] The corresponding reaction was found to take place with 2-fluoro-2,2-dinitroethanol and hydrazine, to give *N*,*N′*-bis(2-fluoro-2,2-dinitroethyl)hydrazine.

$$FC(NO_2)_2CH_2OH + N_2H_4 \longrightarrow FC(NO_2)_2CH_2NHNHCH_2CF(NO_2)_2$$

We have previously reported the fluorination of methyl (2-fluoro-2,2-dinitroethyl)carbamate to give methyl *N*-fluoro-*N*-(2-fluoro-2,2-dinitroethyl)carbamate.[7] This starting material was synthesized by an *in situ* acylation of 2-fluoro-2,2-dinitroethylamine. The addition of methyl chloroformate to the crude solution formed by adding ammonia to aqueous 2-fluoro-2,2-dinitroethanol gave a 20% yield of methyl (2-fluoro-2,2-dinitroethyl)carbamate. In this way, the ethyl and isopropyl esters were also prepared. The preparation of 2-fluoro-2,2-dinitroethylamine derivatives in this way avoids the hazardous[3] isolation of 2-fluoro-2,2-dinitroethylamine.

$$FC(NO_2)_2CH_2OH + NH_3 \longrightarrow FC(NO_2)_2CH_2NH_2 \xrightarrow{ROCOCl} FC(NO_2)_2CH_2NHCO_2R$$

Isopropyl (2-fluoro-2,2-dinitroethyl)carbamate was hydrolyzed in concentrated sulfuric acid to give 2-fluoro-2,2-dinitroethylammonium bisulfate, which was identified in solution by its nmr spectra (see Experimental Section). Dilution of the sulfuric acid solution with ether gave a white solid which was too unstable for analysis.

$$FC(NO_2)_2CH_2NHCO_2CH(CH_3)_2 \xrightarrow{H_2SO_4} FC(NO_2)_2CH_2{}^+NH_3HSO_4{}^-$$

Experimental Section

(2-Fluoro-2,2-dinitroethyl)methylamine.—To a stirred solution of 6.75 g (0.1 mol) of methylamine hydrochloride and 15.4 g (0.1 mol) of 2-fluoro-2,2-dinitroethanol in 100 ml of water at 25° was added dropwise (5 min) a solution of 4.0 g (0.1 mol) of sodium hydroxide in 15 ml of water. After 10 min the reaction mixture was extracted with 50 ml of carbon tetrachloride and the extract was distilled to give 12.0 g (72% yield) of (2-fluoro-2,2-dinitroethyl)methylamine, a pale yellow liquid: bp 32° (0.1 mm); proton nmr (CCl_4) δ 1.29 (s, NH), 2.55 (s, CH_3), and 3.83 (d, J_{HF} = 18.7 Hz, CH_2CF); fluorine nmr: ϕ 109.8 (s, br).

Anal. Calcd for $C_3H_6N_3FO_4$: C, 21.6; H, 3.6; N, 25.2; F, 11.4. Found: C, 21.9; H, 3.7; N, 24.8; F, 11.6.

(2-Fluoro-2,2-dinitroethyl)methylamine hydrochloride, mp 120–121°, was obtained in 85% yield by reacting the amine with ethanolic hydrogen chloride. The salt precipitated upon addition of diethyl ether.

Anal. Calcd for $C_3H_7N_3FClO_4$: C, 17.7; H, 3.5; N, 20.6; F, 9.3. Found: C, 17.6; H, 3.5; N, 20.6; F, 9.4.

(2-Fluoro-2,2-dinitroethyl)dimethylamine.—The title compound, a pale yellow liquid, bp 23–24° (0.1 mm), was obtained in 78% yield following the above procedure.

Anal. Calcd for $C_4H_8N_3FO_4$: C, 26.5; H, 4.4; N, 23.2; F, 10.4. Found: C, 26.5; H, 4.7; N, 22.8; F, 10.0.

(2-Fluoro-2,2-dinitroethyl)dimethylamine hydrochloride, mp 110–111°, was obtained, in 92% yield from the amine following the above-described procedure.

Anal. Calcd for $C_4H_9N_3FClO_4$: C, 22.1; H, 4.2; N, 19.3; F, 8.7. Found: C, 22.0; H, 4.4; N, 18.7; F, 8.9.

(2-Fluoro-2,2-dinitroethyl)aminoacetic Acid.—A solution of 4.0 g (0.1 mol) of sodium hydroxide in 15 ml of water was added dropwise (5 min) at 0–3° to a stirred solution of 15.4 g (0.1 mol) of 2-fluoro-2,2-dinitroethanol and 7.5 g (0.1 mol) of glycine in 50 ml of water. The solution turned turbid and deposited a white solid. After 30 min the reaction mixture was acidified with 20% hydrochloric acid. The solid was filtered, washed with water, and air-dried to give 13.5 g (64% yield), mp 75–76°. Recrystallization from methylene chloride gave a white, crystalline solid, mp 76°.

The infrared spectrum showed the following major peaks (μ): 2.90, 3.70, 3.93, 5.70, 5.80, 6.30, 7.62, 8.12, 11.72, and 12.50. Proton nmr (acetone-d_6–$CDCl_3$) showed δ 6.31 (3, NH and COOH), 3.97 (d, J_{HF} = 18.0 Hz, CH_2CF), and 3.57 (s, CH_2COO); fluorine nmr ϕ 109.7 (t, J_{HF} = 18.1).

Anal. Calcd for $C_4H_6N_3FO_6$: C, 22.8; H, 2.8; N, 19.9; F, 9.0. Found: C, 22.6; H, 2.6; N, 19.7; F, 9.0.

Ethyl 2-Fluoro-2,2-dinitroethylaminoacetate.—A solution of 1.6 g (0.04 mol) of sodium hydroxide in 15 ml of water was added dropwise at 0–5° to a stirred solution of 5.6 g (0.04 mol) of glycine ethyl ester hydrochloride and 6.24 g (0.04 mol) of 2-

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[6] M. B. Frankel and K. Klager, *J. Amer. Chem. Soc.*, **79**, 2953 (1957).

[7] V. Grakauskas and K. Baum, *J. Org. Chem.*, **34**, 2840 (1969).

fluoro-2,2-dinitroethanol in 75 ml of water. The resulting mixture was stirred for 20 min and then was extracted with 35 ml of methylene chloride. The methylene chloride extract was distilled to give 9.3 g (97% yield) of ethyl 2-fluoro-2,2-dinitroethylaminoacetate, a colorless liquid: bp 95° (0.1 mm); proton nmr (CCl_4) δ 4.02 (d, d, J_{HF} = 18, J_{H-NH} = 7.5 Hz, $-CH_2CF-$), 4.17 (q, J = 7.5 Hz, $-COOCH_2-$), 3.47 (d, J = 6.8 Hz, $-CH_2-$CO-), 2.24 (quintet, J = 6.8 Hz, NH), and 1.27 (t, J = 7.5 Hz, CH_3). After D_2O exchange the δ 4.02 quartet was reduced to a doublet, the $-CH_2O-$ doublet was reduced to a singlet, and the NH- quintet was eliminated. Fluorine nmr showed ϕ 110.2 (t, J_{HF} = 18.3 Hz).

Anal. Calcd for $C_6H_{10}N_3FO_6$: C, 30.1; H, 4.2; N, 17.6; F, 7.9. Found: C, 29.8; H, 3.9; N, 17.5; F, 7.9.

(2-Fluoro-2,2-dinitroethyl)aminoacetaldehyde Diethyl Acetal.—To a solution of 3.1 g (0.02 mol) of 2-fluoro-2,2-dinitroethanol in 25 ml of ice water was added with stirring 2.2 g (0.017 mol) of aminoacetaldehyde diethyl acetal. The reaction mixture was stirred for 1 hr at 10–15° and then extracted with 25 ml of methylene chloride. The extract was distilled to give 4.2 g (94% yield) of a pale yellow liquid: bp 94–95° (0.1 mm); proton nmr (undiluted sample) δ 1.21 (t, J = 7.5 Hz, CH_3), 3.6 (m, OCH_2), 1.92 (s, NH), 2.80 (d, NCH_2), 4.01 (d, J_{HF} = 17.8 Hz, CH_2CF), and 4.50 (t, OCHO); fluorine nmr ϕ 109.5 (t, J_{HF} = 18.0 Hz).

Anal. Calcd for $C_8H_{16}N_3FO_6$: C, 35.7; H, 5.9; N, 15.6; F, 7.1. Found: C, 35.1; H, 5.7; N, 15.4; F, 6.8.

(2-Fluoro-2,2-dinitroethyl)aminosuccinic Acid.—To a stirred suspension of 15.4 g (0.1 mol) of 2-fluoro-2,2-dinitroethanol and 13.3 g (0.1 mol) of *dl*-aspartic acid in 200 ml of water was added with stirring at 15° a solution of 8.0 g (0.2 mol) of sodium hydroxide in 15 ml of water. The reaction mixture was stirred for 30 min and then was acidified with 20 g of concentrated hydrochloric acid. A white amorphous solid was collected, washed with water, and air-dried to give 21 g (78% yield): mp 140–142°; proton nmr (acetone-d_6) δ 8.30 (s, NH and COOH), 4.31 (double AB quartet, J_{AB} = 15.1, J_{AF} = J_{BF} = 15.0 Hz, CH_2CF), 3.83 (t, J_{HH} = 6.0 Hz, CH), and 2.82 (d, J_{HH} = 6.0 Hz, CH_2COO); fluorine nmr ϕ 109.8 (m).

Anal. Calcd for $C_6H_8N_3FO_8$: C, 27.0; H, 3.0; N, 15.7; F, 7.1. Found: C, 26.8; H, 3.0; N, 15.1; F, 7.0.

2-(2-Fluoro-2,2-dinitroethylamino)ethanol.—2-Aminoethanol, 6.1 g (0.1 mol), was added dropwise at 0–3° to a stirred solution of 15.4 g (0.1 mol) of 2-fluoro-2,2-dinitroethanol in 75 ml of water. The reaction mixture was stirred at 22° for 45 min and then was extracted with two 35-ml portions of methylene chloride. The combined extracts were concentrated and dried at 80° (0.1 mm) to give 14.5 g (74% yield) of pale yellow liquid. An analytical sample was distilled in a molecular still at 75–80° (0.005 mm).

Anal. Calcd for $C_4H_8N_3FO_5$: C, 24.4; H, 4.1; N, 21.3; F, 9.6. Found: C, 24.1; H, 4.0; N, 21.3; F, 9.5.

The differential thermal analysis exhibited a sharp exotherm at 128°, with onset of exotherm at *ca.* 93°.

***N*-(2-Fluoro-2,2-dinitroethyl)allylamine.**—2-Fluoro-2,2-dinitroethanol, 6.24 g (0.04 mol), was added dropwise (10 min) at 0–10° to a stirred solution of 2.3 g (0.04 mol) of allylamine in 40 ml of water. A water-insoluble liquid separated instantaneously. After 10 min the reaction mixture was extracted with 30 ml of methylene chloride and the extract was distilled to give 5.8 g (75% yield) of *N*-(2-fluoro-2,2-dinitroethyl)allylamine, a pale yellow liquid: bp 64–65° (0.05 mm); proton nmr ($CDCl_3$) δ 5.84 (m, $-CH{=}$), 5.15 (complex d, $=CH_2$), 3.92 (d, J_{HF} = 19.7 Hz, CH_2CF), 3.33 (d, allylic CH_2), and 1.77 (s, NH); fluorine nmr ϕ 109.3 (t, J_{HF} = 20.4 Hz).

Anal. Calcd for $C_5H_8N_3FO_4$: C, 30.1; H, 4.1; N, 21.8; F, 9.8. Found: C, 29.9; H, 3.9; N, 20.9; F, 9.5.

The compound was also prepared in nonaqueous solution as follows. A solution of 5.6 g (0.1 mol) of allylamine in 35 ml of methylene chloride was added dropwise (10 min) at 12–15° to a stirred solution of 15.4 g (0.1 mol) of 2-fluoro-2,2-dinitroethanol in 85 ml of methylene chloride. The reaction mixture was dried with anhydrous sodium sulfate for 2 hr and filtered, and the filtrate was distilled to give 17.9 g (93% yield) of *N*-(2-fluoro-2,2-dinitroethyl)allylamine.

***N*,*N*-Bis(2-fluoro-2,2-dinitroethyl)allylamine.**—A mixture of 2.5 g (0.013 mol) of *N*-(2-fluoro-2,2-dinitroethyl)allylamine (above) and 5.0 g of 2-fluoro-2,2-dinitroethanol was heated at 90–95° for 6 hr. Excess alcohol was removed by distillation and the remaining viscous liquid was distilled in a molecular still at 90–95° (25–50 μ) to give 2.1 g (49% yield) of *N*,*N*-bis(2-fluoro-2,2-dinitroethyl)allylamine, a pale yellow liquid: proton nmr ($CDCl_3$) δ 5.40 (m, $CH{=}CH_2$), 4.11 (d, J_{HF} = 18.0 Hz, CH_2CF), and 3.37 (d, J = 5.5 Hz, allylic CH_2); fluorine nmr ϕ 108.2 (t).

Anal. Calcd for $C_7H_9N_5F_2O_8$: C, 25.5; H, 2.7; N, 21.3; F, 11.6. Found: C, 26.0; H, 2.1; N, 21.2; F, 11.6.

***N*,*N′*-Bis(2-fluoro-2,2-dinitroethyl)-*N*,*N′*-bis(carbethoxymethyl)methylenediamine.**—A mixture of 7.2 g (0.03 mol) of ethyl 2-fluoro-2,2-dinitroethylaminoacetate and 10.0 g (0.065 mol) of 2-fluoro-2,2-dinitroethanol was heated at 115–120° for 4.5 hr. The solution was cooled to 80° and excess of the alcohol was removed at reduced pressure. The residue crystallized on standing at 25° for several days, and was recrystallized from methanol to give 5.3 g of white solid, mp 87°. The infrared spectrum showed no absorption in the OH or NH region, a strong CO at 5.78 μ, and NO_2 at 6.26 μ. Proton nmr ($CDCl_3$) showed δ 1.32 (t, J_{HH} = 7.1 Hz, CH_3), 3.44 (s, CH_2COO), 3.90 (s, NCH_2N), 4.10 (d, J_{HF} = 19.0 Hz, CH_2CF), and 4.20 (q, J_{HH} = 7.2 Hz, OCH_2); area ratio 3:2:1:2:2; fluorine nmr ϕ 110.0 (t, J_{HF} = 19 Hz.).

Anal. Calcd for $C_{13}H_{20}N_6F_2O_{12}$: C, 31.8; H, 4.1; N, 17.2; F, 7.8. Found: C, 32.1; H, 4.1; N, 17.3; F, 7.8.

***N*,*N′*-Bis(2-fluoro-2,2-dinitroethyl)hydrazine.**—A solution of 1.25 g (0.025 mol) of hydrazine hydrate and 7.7 g (0.05 mol) of 2-fluoro-2,2-dinitroethanol in 220 ml of water was allowed to stand at 0° for 4 days. A pale yellow solid was washed with water, dried, and crystallized from chloroform to give 1.5 g (20% yield) of *N*,*N′*-bis(2-fluoro-2,2-dinitroethyl)hydrazine, mp 61–62°. The differential thermal analysis exhibited an endotherm at 61° and the exotherm at 141° (onset at *ca.* 116°). Proton nmr (acetone-d_6) showed δ 4.98 (m, 2 NH) and 4.19 (d, d, J_{HF} = 17.5, J_{HNH} = 5.2 Hz, CH_2CF); fluorine nmr ϕ 109.0 (t). When the proton spectrum was recorded at −50°, the NH signal appeared as a resolved triplet and the CH_2 signal retained its profile. The proton nmr spectrum in acetone-d_6–methylene chloride mixture exhibited a broadened doublet at δ 4.10 (J = 13.0 Hz), and a broad singlet at δ 4.21. The latter signal disappeared in D_2O exchange.

Anal. Calcd for $C_4H_6N_6F_2O_8$: C, 15.8; H, 2.0; N, 27.6; F, 12.5. Found: C, 16.1; H, 1.8; N, 26.8; F, 12.4.

Ethyl (2-Fluoro-2,2-dinitroethyl)carbamate.—To a stirred solution of 15.4 g (0.1 mol) of 2-fluoro-2,2-dinitroethanol in 70 ml of water at 25° was added dropwise (5 min) 6.0 g of 28% ammonium hydroxide (0.1 mol of NH_3). Some yellow oil deposited. After 30 min, 5.4 g (0.05 mol) of ethyl chloroformate was added. The mixture was stirred for 10 min and a solution of 4.0 g (0.1 mol) of sodium hydroxide in 25 ml of water and another 5.4 g of ethyl chloroformate were added. After 25 min the reaction mixture was extracted with 50 ml of methylene chloride and the extract was distilled to give 15.0 g of 2-fluoro-2,2-dinitroethyl ethyl carbonate, bp 54° (0.1 mm), $n^{25}{}_D$ 1.4212 [lit.[8] bp 53–54° (0.1 mm)]. Further distillation yielded 4.0 g of ethyl (2-fluoro-2,2-dinitroethyl)carbamate, a colorless liquid: bp 85° (0.1 mm); proton nmr (CCl_4) δ 1.23 (t, CH_3 of C_2H_5), 4.10 (q, OCH_2), 4.46 (q, J_{HF} = 15.1 Hz, CH_2CF), and 5.93 (t, NH); fluorine nmr ϕ109.5 (t, J_{HF} = 14.9 Hz).

Anal. Calcd for $C_5H_8N_3FO_6$: C, 26.7; H, 3.6; N, 18.7; F, 8.4. Found: C, 26.6; H, 3.9; N, 17.8; F, 9.0.

Methyl (2-Fluoro-2,2-dinitroethyl)carbamate.—The title compound, a white solid, mp 40–41°, was obtained in 20% yield by treating an ammoniacal solution of 2-fluoro-2,2-dinitroethanol with methyl chloroformate as described above.

Anal. Calcd for $C_4H_6N_3FO_6$: C, 22.8; H, 2.9; N, 19.9; F, 9.0. Found: C, 22.8; H, 3.2; N, 20.1; F, 9.1.

Isopropyl (2-Fluoro-2,2-dinitroethyl)carbamate.—The title compound, mp 47–48°, was obtained in 30% yield (together with larger quantities of 2-fluoro-2,2-dinitroethyl isopropyl carbonate) in the reaction of 2-fluoro-2,2-dinitroethanol with aqueous ammonia and isopropyl chloroformate following the above procedure.

Anal. Calcd for $C_6H_{10}N_3FO_6$: C, 30.1; H, 4.2; N, 17.6; F, 7.9. Found: C, 29.9; H, 3.9; N, 16.8; F, 7.9.

2-Fluoro-2,2-dinitroethylammonium Bisulfate.—Isopropyl (2-fluoro-2,2-dinitroethyl)carbamate (0.2 g) was added with stirring to 1.0 ml of concentrated sulfuric acid at 0–5°. Carbon dioxide was evolved. After 15 min the reaction mixture was added to 50 ml of diethyl ether and the solution was kept at −15° for 18 hr. A white crystalline solid was filtered and washed with four 10-ml portions of diethyl ether. The solid fumed off soon after washing.

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The above reaction was repeated and the sulfuric acid solution of the salt was examined by nmr. Proton nmr: δ 6.60 (s, broad, A = 153, NH_3^+) and 4.00 (d, q, J_{HF} = 11.0, J_{NH-H} = 6.0 Hz, A = 102, CH_2); fluorine nmr ϕ 101.0 (t, J_{HF} = 10.4 Hz).

Registry No.—2-Fluoro-2,2-dinitroethanol, 17003-75-7; (2-fluoro-2,2-dinitroethyl)methylamine, 30409-33-7, 30409-34-8 (HCl); (2-fluoro-2,2-dinitroethyl)-dimethylamine, 30409-35-9, 30409-36-0 (HCl); (2-fluoro-2,2-dinitroethyl)aminoacetic acid, 30409-37-1; ethyl 2-fluoro-2,2-dinitroethylaminoacetate, 30409-38-2; (2-fluoro-2,2-dinitroethyl)aminoacetaldehyde diethyl acetal, 30409-39-3; (2-fluoro-2,2-dinitroethyl)-aminosuccinic acid, 30476-99-4; 2-(2-fluoro-2,2-dinitroethylamino)ethanol, 30409-40-6; N-(2-fluoro-2,2-dinitroethyl)allylamine, 30409-41-7; N,N-bis(2-fluoro-2,2-dinitroethyl)allylamine, 30409-42-8; N,N'-bis(2-fluoro-2,2-dinitroethyl)-N,N'-bis(carbethoxymethyl)-methylenediamine, 29925-43-7; N,N'-bis(2-fluoro-2,2-dinitroethyl)hydrazine, 30409-44-0; ethyl (2-fluoro-2,2-dinitroethyl)carbamate, 30409-45-1; methyl (2-fluoro-2,2-dinitroethyl)carbamate, 30409-46-2; isopropyl (2-fluoro-2,2-dinitroethyl)carbamate, 30409-47-3; 2-fluoro-2,2-dinitroethylammonium bisulfate, 30409-48-4.

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The Reaction of Ethyl β-Dimethylaminocrotonate and Benzoyl Isothiocyanate

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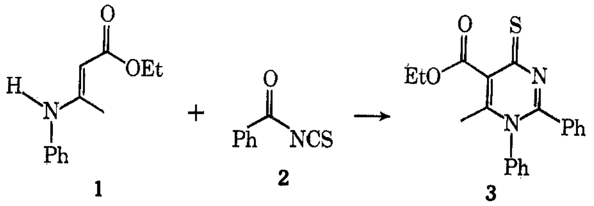
The reaction of ethyl β-dimethylaminocrotonate and benzoyl isothiocyanate in chloroform to yield ethyl 2-benzamido-5-benzoyl-4-dimethylamino-6-thioxonicotinate is described and the crystal structure analysis given. The intermediates leading to the product and the pathway of formation are discussed.

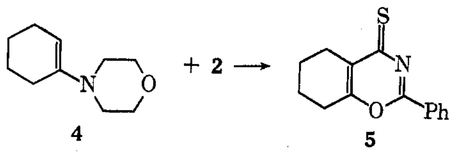
Part A

Enamines have been used to synthesize various carbocyclic and heterocyclic systems.[1] Our interest has been in the synthesis of pyrimidines[2] and tetrahydroquinazolines[3] by the interaction of an enamine with benzoyl isothiocyanate.

This paper is concerned with the novel product formed from the reaction of an α,β-unsaturated amino ester, ethyl dimethylaminocrotonate, with benzoyl isothiocyanate. We earlier observed that, when β-anilinocrotonate (1) and benzoyl isothiocyanate (2) were allowed to react, the thiopyrimidine 3 was obtained, whereas, when an enamine 4 derived from a secondary amine was allowed to react with 2, the oxazinethione 5 resulted. It was, therefore, expected that the condensation of β-dimethylamino crotonate (6) with 2 would give rise to the analogous product 7 from which various N-substituted pyrimidines could be prepared (see Scheme I).



1 2 3



4 5

When 6 was allowed to react with 2 in chloroform with warming on a steam bath, a yellow crystalline compound 11, mp 233–235°, was obtained. Elemental analysis indicated that 2 equiv of 2 and 1 equiv of 6 had combined with the loss of hydrogen sulfide. The simplicity of the pmr (ester, dimethylamino, aromatic, and two exchangable protons) and the carbonyl region of the ir was in agreement with the assigned structure.

The reaction pathway proceeds most likely through the addition of 2 equiv of benzoyl isothiocyanate to the α carbon of the crotonate with subsequent internal benzoyl displacement with loss of isothiocyanate or by the addition of 1 equiv of 2 to the α carbon with direct nucleophilic addition of benzoyl to carbon 4. Cyclization with loss of hydrogen sulfide gives 8a which adds thiocyanate with ring opening and enamine reclosure to give 11 (see Scheme I). An alternate pathway that envisions the addition of benzoyl isocyanate to both the 2 and 4 positions of the aminocrotonate does not occur as has been observed in similar reactions.[4,5]

Methylation of 11 with 1 and 2 equiv of methyl iodide gave the mono- and dialkylated products 14 and 12. Ethanolysis of 12 with sodium ethoxide yielded the debenzoylated product 13, whereas treatment of 12 with sodium hydroxide under vigorous conditions yielded, after adjustment of the pH to 7, compound 15 devoid of the carbethoxy and benzoyl groups. Under similar treatment 14 gave 16 and 17. Inspection of the pmr indicates that the NH of 15 which appears at δ 4.68 is shifted downfield to 7.3 when bonded to an α-carboethoxy group as in 13. A similar downfield shift is found in 16 and 17 and is analogous to the

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