SYNTHESIS AND PROPERTIES OF FLUORONITRO ALCOHOLS

COMMUNICATION 4. 2-FLUORO-2-NITRO-1-ALKANOLS AND SOME OF THEIR ESTERS

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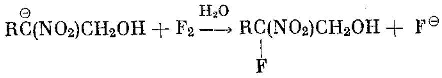
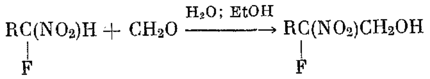
A method for the preparation of 2-fluoro-2-nitro-1-alkanols by the fluorination of the nitronate salts of 2-nitro-1-alkanols in aqueous solution was described in [1, 2]:



$$R\overset{\ominus}{C}(NO_2)CH_2OH + F_2 \xrightarrow{H_2O} R\underset{F}{C}(NO_2)CH_2OH + F^{\ominus}$$

Despite the availability of the starting nitro alcohols and the simplicity of the method, it is impossible to call it an excellent procedure, since under aqueous fluorination conditions the degree to which the 2-nitro-1-alkanol is converted to the corresponding 2-fluoro-2-nitro-1-alkanol is 20-40% in most cases, i.e., the end product always contains a substantial amount of the starting nitro alcohol, and it is necessary to carefully separate the obtained mixture. In [1, 2] the separation was effected by repeated fractional distillation in vacuo through various types of columns, which is complicated and inefficient for the given systems.

In order to obtain the pure 2-fluoro-2-nitro-1-alkanols we employed the Henry reaction, where we used the 1-fluoro-1-nitroalkanes described by us previously [3]. The reaction for the formation of the 2-fluoro-2-nitro-1-alkanols is quite complete, and the yield of the desired products reaches 80-90%:



$$R\underset{F}{C}(NO_2)H + CH_2O \xrightarrow{H_2O;\ EtOH} R\underset{F}{C}(NO_2)CH_2OH$$

The 2-fluoro-2-nitro-1-alkanols obtained by the Henry reaction are easily purified by vacuum-distillation, and in this case a good relationship is achieved between the physical constants of the fluoronitro alcohols as regards the functions: $d_4^{20} = f(H)$ (where H is the amount of hydrogen) [4] and $d_4^{20} = f(n_D^{20})$ [5] (Fig. 1). Some of the physical properties of the synthesized 2-fluoro-2-nitro-1-alkanols, the yields, and the analysis data are given in Table 1.

In contrast to their nitro analogs and the starting 2-nitro-1-alkanols, the 2-fluoro-2-nitro-1-alkanols are not deformulated in the presence of bases [1, 2], which makes it possible to use them in reactions that proceed in alkaline media. For example, the 2-fluoro-2-nitrohexyl ester of picric acid was obtained by employing the method given in [6]:

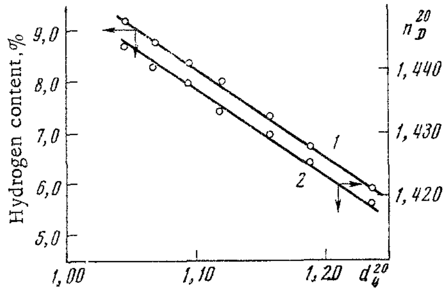


Fig. 1. Dependence of density on amount of hydrogen in the molecule (1) and on the refractive index (2) in the homologous series of 2-fluoro-2-nitro-1-alkanols. $d_4^{20} = 1.598-0.061$ H (1); $d_4^{20} = 12.146-7.692\, n_D^{20}$ (2).

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TABLE 1

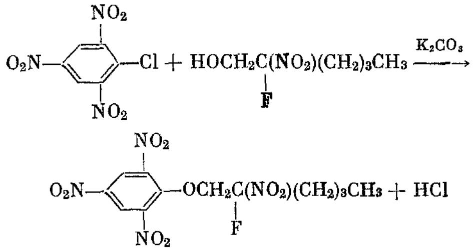
Compound	Yield, %	Bp, °C (p, mm of Hg)	n_D^{20}	d_4^{20}	Found, %				Calculated, %			
					C	H	N	F	C	H	N	F
$CH_3CH_2C(NO_2)FCH_2OH$	80	58—59 (0,5—1)	1,4182	1,2365	35,3	5,8	10,3	13,3	35,04	5,88	10,21	13,85
$CH_3(CH_2)_2C(NO_2)FCH_2OH$	87	65—66 (0,5—1)	1,4250	1,1874	39,6	6,6	9,2	12,4	39,74	6,67	9,26	12,57
$CH_3(CH_2)_3C(NO_2)FCH_2OH$	86	78—79 (0,5—1)	1,4296	1,1572	40,0	7,4	8,2	11,3	40,22	7,32	8,48	11,50
$CH_3(CH_2)_4C(NO_2)FCH_2OH$	79	84—85 (0,2—0,3)	1,4336	1,1186	46,9	7,7	7,5	10,2	46,92	7,87	7,81	10,60
$CH_3(CH_2)_5C(NO_2)FCH_2OH$	83	86—87 (0,1—0,15)	1,4376	1,0944	49,6	8,4	7,2	9,6	49,73	8,34	7,25	9,83
$CH_3(CH_2)_6C(NO_2)FCH_2OH$	85	107—108 (0,5—1)	1,4406	1,0667	52,3	8,6	6,4	9,0	52,06	8,75	6,75	9,16
$CH_3(CH_2)_7C(NO_2)FCH_2OH$	81	105—106 (0,09—0,1)	1,4435	1,0443	54,3	9,2	6,3	8,2	54,28	9,11	6,33	8,58

TABLE 2

Compound	Yield, %	Bp, °C (p, mm of Hg) or mp, °C	n_D^{20}	d_4^{20}	Found %				Calculated %			
					C	H	N	F	C	H	N	F
2-Fluoro-2-nitro-1-hexanol acetate	87	71—72 (0,1—0,2)	1,4237	1,1305	46,3	6,7	6,7	8,8	46,37	6,81	6,75	9,16
2-Fluoro-2-nitro-1-octanol acetate	88	92—93 (0,1—0,2)	1,4295	1,0827	51,2	7,4	5,6	7,8	51,05	7,71	5,95	8,07
2-Fluoro-2-nitro-1-butanol acrylate	42	54—55(1,0)	1,4389	1,1797	43,7	5,0	7,6	9,7	43,98	5,27	7,33	9,94
2-Fluoro2-nitro-1-pentanol acrylate	54	69—70(1,0)	1,4371	1,1489	46,5	5,6	7,0	9,5	46,83	5,89	6,83	9,26
2-Fluoro-2-nitro-1-decanol methacrylate	52	106—107(1,0)	1,4448	1,0458	57,8	8,2	5,1	6,9	58,12	8,36	4,84	6,57
2-Fluoro-2-nitro-1-heptanol tosylate	73	51—52			50,3	5,8	4,2	5,2	50,43	6,04	4,20	5,69
2-Fluoro-2-nitro-1-octanol tosylate	68	54—55			51,4	6,0	3,9	5,1	51,85	6,38	4,03	5,46
2-Fluoro-2-nitrononyl-4'-fluoro-4', 4'-dinitrobutyrate	70	56—57			40,8	5,1	10,7	9,4	40,52	5,49	10,90	9,86
2-Fluoro-2-nitrodecyl 4'-fluoro-4', 4'-dinitrobutyrate	71	60—61			41,8	5,6	10,4	9,3	42,10	5,80	10,52	9,51
2-Fluoro-2-nitroheptyl N-(3'-fluoro-3-', 3'-dinitropropyl) carbamate	41	37—38			36,9	4,9	8,2	11,3	36,37	4,88	8,48	11,51
2-Fluoro-2-nitrononyl N-(3' fluoro-3', 3'-dinitropropyl)carbamate	57	43—44			40,4	5,4	7,8	10,2	40,23	5,63	7,82	10,60
1-(2'-Fluoro-2'-nitrohexoxy)-2,4,6-trinitrobenzene	82	110—111			38,1	3,4	14,5	5,3	38,30	3,48	14,89	5,04

TABLE 3

Nitrate	Yield,%	Bp, °C (p, mm of Hg)	n_D^{20}	d_4^{20}	Found %				Calculated %			
					C	H	N	F	C	H	N	F
2-Fluoro-2-nitro-1-butanol	79	55—51(1,0)	1,4278	1,3722	26,1	3,7	15,7	10,2	26,38	3,87	15,38	10,43
2-Fluoro-2-nitro-1-pentanol	83	80—81(1,0)	1,4313	1,2988	30,4	4,4	14,5	9,8	30,62	4,62	14,28	9,69
2-Fluoro-2-nitro-1-octanol	86	91—92(1,0)	1,4385	1,1801	40,6	6,2	11,8	8,1	40,33	6,35	11,76	7,98
2-Fluoro-2-nitro-1-decanol	88	103—104(1,0)	1,4425	1,1299	45,4	7,0	10,4	7,2	45,11	7,19	10,52	7,12



The hydroxyl group in the 2-fluoro-2-nitro-1-alkanols is easily esterified by acids and acid chlorides. Some of the arbitrarily selected alcohols were esterified with acetyl chloride, p-toluene-sulfonyl chloride and 4-fluoro-4,4-dinitrobutyryl chloride. The esters of some unsaturated acids (acrylic and methacrylic) and the esters of 3-fluoro-3,3-dinitropropylcarbamic acid were also obtained in satisfactory yields (Table 2). Four 2-fluoro-2-nitro-1-alkanol nitrates were synthesized (Table 3), for which the functions $d_4^{20} = f(H)$ and $d_4^{20} = f(n_D^{20})$ proved to be quite satisfactory.

EXPERIMENTAL METHOD

2-Fluoro-2-nitro-1-alkanols. To a solution of 0.1 M of the 1-fluoro-1-nitroalkane and 10 ml of 36% formalin solution in 30 ml of ethanol was added in drops, at 20°C, 1-2 ml of a 2% solution of either caustic or Triton B. After holding at 78-80° for 2-3 h the reaction mass was cooled and diluted with water. The product was extracted with ether, and the combined extracts were washed with water (2 × 50 ml) and then dried over $MgSO_4$. After removal of the solvent the 2-fluoro-2-nitro-1-alkanol was purified by vacuum-distillation.

Nitrates of 2-Fluoro-2-nitro-1-alkanols. To a mixture of 0.25 M of 98% HNO_3 and 0.25 M of 94% H_2SO_4 at 0° was added 0.05 M of the 2-fluoro-2-nitro-1-alkanol, after which the mixture was held for 2 h and then gradually heated up to 18-20°. The reaction mass was poured on 50 g of ice. The organic layer was separated and dissolved in 10 ml of ether. The ether solution was washed with 5% aqueous $NaHCO_3$ solution and then dried over $MgSO_4$. After removal of the solvent the 2-fluoro-2-nitro-1-alkanol nitrate was purified by vacuum-distillation.

Acetates of 2-Fluoro-2-nitro-1-alkanols. To a solution of 0.1 M of the 2-fluoro-2-nitro-1-alkanol in 30 ml of 1,2-dichloroethane at 18-20° was added in drops a solution of 0.11 M of acetyl chloride in 20 ml of 1,2-dichloroethane. At the end of gas evolution the reaction mass was slowly heated up to reflux and held for 3-3.5 h. After removal of the low-boiling components the 2-fluoro-2-nitro-1-alkanol acetate was purified by vacuum-distillation.

Acrylates and Methacrylates of 2-Fluoro-2-nitro-1-alkanols. To a solution of 0.05 M of the 2-fluoro-2-nitro-1-alkanol in 50 ml of $CHCl_3$ was added 0.055 M of the appropriate acid chloride. The mixture was held at 70-75° for 6 h. After removal of the solvent the ester was washed in succession with water and 5% $NaHCO_3$ solution and then dried over $MgSO_4$. For final purification the ester was vacuum-distilled.

Tosylates of 2-Fluoro-2-nitro-1-alkanols. To a solution of 0.1 M of the 2-fluoro-2-nitro-1-alkanol in 0.4 M of pyridine at 0-5° was added 0.11 M of p-toluenesulfonyl chloride in portions. The mixture was carefully heated up to 75-80° and held for 3-4 h. After cooling, 100 ml of CH_2Cl_2 was added and the mixture was poured into a mixture of water and ice that contained ~0.3 M of HCl. The organic layer was separated, washed in succession with 5% $KHCO_3$ solution and water, and then dried over $MgSO_4$. The dry solution was filtered through a bed of Al_2O_3 and then evaporated. The precipitate was recrystallized twice from heptane.

2-Fluoro-2-nitroalkyl-4'-fluoro-4',4'-dinitrobutyrates. To a solution of 0.1 M of the 2-fluoro-2-nitro-1-alkanol and 0.11 M of the acid chloride of 4-fluoro-4,4-dinitrobutanoic acid in 70 ml of 1,2-dichloroethane at 10-12° was added 0.1 M of anhydrous $AlCl_3$ in portions; the mixture was slowly heated up to 83-85° and held for 2.5-3 h. The chilled reaction mass was poured into a mixture of 5% HCl solution and ice. The organic layer was separated, washed in succession with 2% $KHCO_3$ solution and water, and then dried over $MgSO_4$. The solvent was evaporated, while the crystalline product was recrystallized several times from heptane.

2-Fluoro-2-nitroalkyl-N-(3'-fluoro-3',3'-dinitropropyl)carbamates. To a solution of 0.07 M of NaN_3 in 15 ml of water at 0-3° was added in drops a solution of 0.035 M of the acid chloride of 4-fluoro-4,4-dinitrobutanoic acid in 30 ml of $CHCl_3$. The reaction mass was heated up to 30° and held for 30 min. After cooling to 18-20° the chloroform layer was separated, while the aqueous solution was extracted with $CHCl_3$ (3 × 5 ml). The combined solution was washed with water (2 × 25 ml) and then dried over $MgSO_4$. To the solution were added 0.035 M of the 2-fluoro-2-nitro-1-alkanol and a catalytic amount of ferric acetylacetonate. The mixture was refluxed for 5 h. Then the $CHCl_3$ was removed, while the residue was recrystallized twice from a CCl_4–heptane mixture.

1-(2'-Fluoro-2'-nitrohexoxy)-2,4,6-trinitrobenzene. To a solution of 0.05 M of 2-fluoro-2-nitro-1-hexanol and 0.05 M of picryl chloride in 20 ml of benzene at 0-3° was added 0.051 M of anhydrous K_2CO_3 in portions. After stirring at 18-20° for 24 h the precipitate was separated and the benzene was removed from the filtrate. The crystalline precipitate was recrystallized from a 2:1 CCl_4–heptane mixture, and then twice from heptane.

CONCLUSIONS

1. A mixture of 2-fluoro-2-nitro-1-alkanols and some of their esters were synthesized by the Henry reaction.

2. It was shown for the synthesized alcohols and their nitrates that a good relationship exists between the density and the amount of hydrogen and refractive index.

LITERATURE CITED

1. L. T. Eremenko and G. V. Oreshko, Izv. Akad. Nauk SSSR, Ser. Khim., 1969, 380.
2. K. Baum, J. Org. Chem., 35, 846 (1970).
3. F. Ya. Natsibullin, G. V. Oreshko, and L. T. Eremenko, Izv. Akad. Nauk SSSR, Ser. Khim., 1971, 2344.
4. L. T. Eremenko, Izv. Akad. Nauk SSSR, Ser. Khim., 1968, 1064.
5. A. M. Korolev and L. T. Eremenko, Izv. Akad. Nauk SSSR, Ser. Khim., 1972, 182.
6. H. G. Adolph and M. J. Kamlet, J. Org. Chem., 34, 45 (1969).