NOTES

The Potassium Fluoride-Catalyzed Reaction. V. Aldol Condensation of Nitroalkanes and Aliphatic Aldehydes

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Midorikawa and his collaborators first reported base-catalyzed reactions by potassium fluoride.[1a-f] This apparent basic property of the fluoride was recently illustrated by Rand *et al.*[2a-d] and by LeGoff.[3] In extension of our own previous studies,[4,5] the action of nitroalkanes on aliphatic aldehydes under the catalytic influence of the fluoride has now been investigated. In general, most aldehydes, especially paraformaldehyde, react conventionally with nitroalkanes in the presence of bases, giving the next higher homologs, or mixtures of them and non-distillable materials.[6,7] The condensation of paraformaldehyde and nitromethane, for example, readily afforded the final tris-product, nitroisobutylglycerol, along with a very poor yield of 2-nitroethanol (I). More recently, Namba and Yamashita[8] reported a convenient method for the preparation of the alcohol (I) using ethanolic potash, but the yield was only 25%. The nitroalcohol (I), on the other hand, can be obtained from ethylene and fuming nitric acid[9] or liquid nitrogen peroxide on direct nitration, although, these procedures have not generally been utilized in synthesis.

In the present base-catalyzed reaction of nitromethane with paraformaldehyde, it is noted that the yield of I is very high (73%) and is dependent upon the concentration of potassium fluoride used. The use of 0.05 mol of the fluoride per mol of paraformaldehyde appreciably alters the yield of I. Furthermore, the nature of the solvent has a remarkable effect on the rate of the reaction and on the product yield; thus, as is shown in Table 1, the 2-nitroethanol formation in isopropanol consistently gives higher yields than those in other solvents. The polymer formation may be avoided completely at temperatures below 50°C. It is difficult to isolate pure di- or tri-hydric derivatives in any case.

A systematic study of the aldol condensation of

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[2] a) L. Rand and M. J. Albinak, *J. Org. Chem.*, **25**, 1837 (1960); b) L. Rand, W. Wagner, P. O. Warner and L. R. Kovac, *ibid.*, **27**, 1034 (1962); c) L. Rand, J. V. Swisher and C. J. Cronis, *ibid.*, **27**, 3505 (1962); d) L. Rand, D. Haidukewych and R. J. Dolinski, *ibid.*, **31**, 1272 (1966).

[3] E. LeGoff, *J. Am. Chem. Soc.*, **84**, 3975 (1962).

[4] S. Kambe and H. Yasuda, *Sci. Papers Inst. Phys. Chem. Res.*, **58**, 148 (1964).

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[6] M. M. Hollemann, *Rec. trav. chim.*, **23**, 298 (1904).

[7] B. M. Vanderbilt and H. B. Hass, *Ind. Eng. Chem.*, **32**, 34 (1940).

[8] K. Namba and T. Yamashita, *Kogyo Kayaku*, **12**, 31 (1951).

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Table 1. COMPARATIVE YIELD[a] OF 2-NITROETHANOL (I) OBTAINED FROM NITROMETHANE AND PARAFORMALDEHYDE IN VARIOUS SOLVENTS AND IN VARIOUS CONCENTRATIONS OF POTASSIUM FLUORIDE

Methanol		Ethanol		*n*-Propanol		Isopropanol		*n*-Butanol		Isobutanol	
KF (mol)	Yield (%)	KF (mol)	Yield (%)	KF (mol)	Yield (%)	KF (mol)	Yield (%)	KF (mol)	Yield (%)	KF (mol)	Yield (%)
0.01	20	0.01	25	0.01	28	0.01	29	0.01	10	0.01	7
0.05	35	0.05	37	0.05	57	0.05	73	0.05	15	0.05	7
0.1	32	0.1	35	0.1	40	0.1	59	0.1	9	0.1	6

a) Reaction of 2 mol of nitromethane and 1 mol of paraformaldehyde at 30—35°C for 6 hr; Overall yield from the aldehyde used.

TABLE 2. PHYSICAL CONSTANTS OF NITROALCOHOLS OBTAINED

Nitroalcohol	Prepared from		Bp °C/mmHg	Lit., bp °C/mmHg	Reac. time (hr)	Yield (%)
	Nitroalkane	Aldehyde				
2-Nitro-1-propanol (II)	Nitroethane	Paraformaldehyde	80—81/3	99/10[a]	6	62
2-Nitro-1-butanol (III)	1-Nitropropane	Paraformaldehyde	93—94/5	105/10[a]	6	74
2-Nitro-2-methyl-1-propanol (IV)	2-Nitropropane	Paraformaldehyde	90—91*	90*[a]	6	65
3-Nitro-2-propanol (V)	Nitromethane	Acetaldehyde	77—79/4	89/8[b]	6	44
3-Nitro-2-butanol (VI)	Nitroethane	Acetaldehyde	72—74/2	92/10[a]	6	67
3-Nitro-2-pentanol (VII)	1-Nitropropane	Acetaldehyde	75—77/2	100/10[a]	6	68
3-Nitro-3-methyl-2-butanol (VIII)	2-Nitropropane	Acetaldehyde	82—84/5	90/10[a]	7	70
4-Nitro-3-butanol (IX)	Nitromethane	Propionaldehyde	75—76/5	99/9[b]	7	86
4-Nitro-3-pentanol (X)	Nitroethane	Propionaldehyde	82—84/5	96/8[b]	7	82
4-Nitro-3-hexanol (XI)	1-Nitropropane	Propionaldehyde	87—88/4	89/2[c]	7	73
4-Nitro-4-methyl-3-pentanol (XII)	2-Nitrpropane	Propionaldehyde	78—79/5	75/4[c]	10	56
1-Nitro-2-pentanol (XIII)	Nitromethane	*n*-Butyraldehyde	93—94/3	85/2[c]	10	75
2-Nitro-3-hexanol (XIV)	Nitroethane	*n*-Butyraldehyde	89—90/3	100/10[a]	10	55
3-Nitro-4-heptanol (XV)	1-Nitropropane	*n*-Butyraldehyde	88—89/3	115/10[a]	10	44
2-Nitro-2-methyl-3-hexanol (XVI)	2-Nitropropane	*n*-Butyraldehyde	81—82/4	109/10[a]	10	37
1-Nitro-3-methyl-2-butanol (XVII)	Nitromethane	Isobutyraldehyde	91—92/6	66/1[c]	15	57
2-Nitro-4-methyl-3-pentanol (XVIII)	Nitroethane	Isobutyraldehyde	88—89/2	89/2[c]	15	48
4-Nitro-2-methyl-3-hexanol (XIX)	1-Nitropropane	Isobutyraldehyde	90—91/3	78/2[c]	15	36

* Melting point.
a) B. M. Vanderbilt and H. B. Hass, *Ind. Eng. Chem.*, **32**, 34 (1940).
b) C. D. Hurd and M. E. Nilson, *J. Org. Chem.*, **20**, 927 (1955).
c) D. Nightingale and J. R. Janes, *J. Am. Chem. Soc.*, **66**, 352 (1944).

various nitroalkanes with aliphatic aldehydes was attempted (see Table 2). The solvent employed was isopropanol. In the condensation of paraformaldehyde with a primary nitroalkanes, such as nitroethane or 1-nitropropane, a di-hydric compound can be isolated in a low yield.

There are great differences in reactivity between the aldehydes used; *i. e.*, the yield decreases in the following order:

$$CH_3CHO \approx C_2H_5CHO > n\text{-}C_3H_7CHO > i\text{-}C_3H_7CHO$$

This suggests that the substitution of the methyl group at the α-position of the aldehyde would offer a steric hindrance to nitroalkane addition. The results obtained are shown in Table 2.

Experimental[*1]

Preparation of 2-Nitroethanol (I) (in Isopropanol as a Recommended Solvent). Paraformaldehyde (30 g, 1 mol) was stirred into isopropanol (300 m*l*)

[*1] All boiling and metling points are uncorrected.

containing potassium fluoride (2.9 g, 0.05 mol), and the stirring was continued until the aldehyde had completely dissolved. To a stirred alcoholic solution then was added, drop by drop, nitromethane (120 g, 2 mol) at 30—35°C within 2 hr. After this addition stirring was continued for 4 more hours, and then the catalyst was removed by filtration. The residue, on the removal of the solvent, was poured into water, and the residual oily matter was extracted with ether. After the ethereal extract had then been dried over anhydrous sodium sulfate, the solvent was removed. The desired reaction product was distilled at 86—87°C/4 mmHg was collected (*cf.* Table 1).

Preparation of Other Nitroalcohols. To a mechanically stirred solution of 0.05 mol of potassium fluoride and 1 mol of the appropriate aldehyde in 150 *ml* of isopropanol, then was added, drop by drop, 1 mol of the appropriate nitroalkane below 40°C; the stirring was continued for a suitable period. After the catalyst had then been removed, the residual oily matter was treated by the procedure described above. The results are listed in Table 2.

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