[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF NORTHWESTERN UNIVERSITY]

ALIPHATIC NITRO KETONES

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Alpha nitro ketones which are recorded in the literature include nitroacetone, ω -nitroacetophenone, nitromethyl piperonyl ketone, 2-nitrocyclohexanone, nitro- α -tetralone, and a few others. Among the synthetic methods one finds oxidation of nitro alcohols (1), reactions of ketones with ethyl nitrate (2) or halo ketones with silver nitrite (3), alkaline condensation (4) of benzil with nitromethane to give ω -nitroacetophenone, and cleavage of the pseudonitrosite (5) of benzylideneacetone by alkali into a 1-benzylidene-1-nitroacetone and thence into nitroacetone by reaction with ammonia followed by acidification. A recently reported (6) synthesis of certain aliphatic nitro ketones is the vapor phase nitration at 400° of the analogous ketones. Although the nitrating agent was not stated, presumably it was concentrated nitric acid.

In this reaction, isopropyl ketone gave rise to about a 20% yield of a separable mixture of both 1-nitro- and 2-nitro-2,4-dimethyl-3-pentanone. Propyl ketone yielded 1-nitro-4-heptanone, also in about 20% yield, but no constants were listed and no proof of structure was mentioned other than a positive nitrolic acid reaction. Acetone, similarly nitrated, gave a 5% yield of what was regarded as nitroacetone "in the high-boiling fraction." No crystalline product was separated but the positive evidence cited was a red ferric chloride color test and formation of a yellow silver salt with aqueous silver nitrate.

In 1941, one of us studied the vapor phase nitration of acetone with 70% nitric acid (d. 1.42) in collaboration with James S. Strong (7). Although we also obtained a 5% yield of silver salt we found no reliable evidence for the presence of nitroacetone in the product. In this work acetone and nitric acid were dropped at predetermined rates into the top of a vertically supported Pyrex glass combustion tube heated by an electric furnance. The hot portion of the tube was 2.4 x 76 cm. In 19 experiments performed at temperatures from 275 to 400° the optimum temperature was found to be about 300°. The reaction product was condensed and the water-insoluble layer was separated as the "crude yield".

Consideration of results at 300° listed in Table I shows that the rate of addition of reagents in the range studied did not greatly affect the "crude yield". Two runs made under conditions identical to each other except for the duration, namely, 15 and 40 minutes, gave crude yields of 55 and 68%, respectively; and another pair at 10 and 30 minutes gave crude yields of 47 and 55%, respectively. The highest crude yield (68%) was not obtained with the highest molar ratio of acetone to nitric acid but with a ratio of 1.5:1, whereas only a 49% yield was observed at 1.8:1.

To convert the "crude yield" of product to the "yield after processing" in Table I the material was purified by evaporation *in vacuo* at room temperature, then an ether solution of the residue was washed with 5% sodium bicarbonate

Time, min.	Aastana a	A .: 4 G 1	Crude	e yield	Yield after processing		
	Acetone, g.	Aciu, mi.	g.	% ^b	g.	% ^b	
15	87	63	83	55			
40	87	63	102	68	29.5	20	
15	110	63	85	49	43	25	
10	119	63	85	47		-	
30	123	63	99	53	52.3	28	
15	115	63			58	33	
30	119	63			35	19	
420	2180	1400			860	24	

TABLE I NITRATION OF ACETONE

^a 63 ml. of 70% nitric acid contains 1 mole (63 g.) of nitric acid.

^b % of weight of total reactants.

solution until the water layer became colored. After drying the solution, the ether was removed under diminished pressure. As will be seen, this yield after processing was about one-half to one-third of the crude yield.

The same product was formed by substitution of red fuming nitric acid (95%, d. 1.5) for concentrated acid but the reaction was too vigorous for easy control. Also, the fuming acid reacted vigorously with acetone at room temperature whereas the concentrated acid showed no reaction even when the mixture was heated on a steam bath; but a mixture of acetone and concentrated acid erupted into violence after a dormant period of 2 hours at room temperature. Evaporation of the reaction products yielded a water-insoluble oil, seemingly identical to the one formed in the vapor phase experiments.

The reaction product from the 300° -reactions, purified as described, was comparatively stable in the cold but nitric oxide was always liberated slowly. Solvents, low- or high-boiling, could be distilled off with safety but explosions accompanied efforts to distil the residue. Thus, when a solvent mixture of toluene and ethylene glycol was being removed at 109° (750 mm.), and then at 100° (18 mm.) no trouble was encountered till most of the glycol was removed. Then, at 102° an explosion occurred.

The following facts cast doubt concerning the presence of more than traces of nitroacetone in the product. In the first place, the average of several molecular weight determinations, taken cryoscopically in benzene, was 210, a value double that required for nitroacetone. Secondly, saturated sodium bisulfite solution gave no precipitate with the oil, and no crystalline semicarbazone or 2,4-dinitrophenylhydrazone was obtainable. Thirdly, no cyclic acetal was formed by heating 30 g. of the product with 20 g. of ethylene glycol, 100 ml. of toluene (to remove water azeotropically), and 0.1 g. of *p*-toluenesulfonic acid. Finally, a 0.3-g. portion of sodium salt, precipitated from an alcoholic solution of 3.8 g. of the product with sodium ethoxide, was dissolved in 3 ml. of water and was acidified with an excess of dilute sulfuric acid. No 2,4-dinitrophenylhydrazone of nitroacetone was obtainable from the solution; the dinitrophenylhydrazine was JULY 1955

recovered. We have found in the present work that these derivatives are readily obtainable from authentic nitroacetone.

Synthetic nitroacetone was investigated in the present work. It was prepared from the nitro alcohol by oxidation. Also, 1-nitro-2-butanone, 3-nitro-2-butanone, and 2-nitro-3-pentanone were included in the study.

On standing, nitroacetone decomposed unpredictably. Some dry samples could be kept at 20° for several weeks with no decomposition, while others decomposed completely after one or two days, even at 0° . The three higher ketones were more stable and could be kept at room temperature for several months with only slight discoloration. At one time, however, 1-nitro-2-butanone began to decompose, giving off brown fumes when air was admitted during a distillation. Immediate cooling prevented further decomposition.

The melting point reported for nitroacetone is variable: 46.5° (8), $49-50^{\circ}$ (9), $50-51^{\circ}$ (1). Our synthesis was the same as that of Levy and Scaife (1) but our m.p. was 47° even after repeated crystallizations. Although this is only a difference of $3-4^{\circ}$ it is far too much for a ready explanation, especially since no decomposition occurred on fusion. Remelting after cooling and solidification caused no change in m.p. The crystals of nitroacetone, examined under the polarizing microscope, appeared to be elongated plates (Fig. 1). The plates showed Y parallel to one of the faces. The optic angle was quite large and the birefringence was moderate to strong.

1-Nitro-2-butanone melted at $12-15^{\circ}$ but the other two ketones were oils. All four compounds yielded crystalline 2,4-dinitrophenylhydrazones and crystalline anils. Our anil from nitroacetone, although previously known, melted 8° lower than the m.p. reported by Harries (9). Benzaldehyde condenses with nitro-



acetone as stated by Harries but it was found that butylamine, piperidine, or sodium methoxide could not be substituted for dilute sodium hydroxide as condensing agents. Benzaldehyde did not condense successfully with the other nitro ketones.

Nitroacetone and 1-nitro-2-butanone underwent reaction with hydrogen chloride, either in aqueous or in ether solution, to produce hydroximyl chlorides in high yields: $\text{RCOCH}_2\text{NO}_2 + \text{HCl} \rightarrow \text{RCOCCl}=\text{NOH} + \text{H}_2\text{O}$. This resembles the reaction of ω -nitrostyrene, benzene, and aluminum chloride wherein the product formed (10) was not a nitro compound but a hydroximyl chloride, Ph₂CH--CCl=-NOH.

All of the nitro ketones reacted with ethylene glycol to yield cyclic acetals, nitroacetone and 1-nitro-2-butanone giving better yields than the ketones with a secondary nitro group. The nitro ketones, however, could not be recovered from the nitro acetals in more than traces by hydrolysis with dilute sulfuric acid, but concentrated hydrochloric acid did cause cleavage of the glycol but it gave rise to hydroximyl chlorides in good yield from the acetals containing the primary nitro group:

 $CH_2 \longrightarrow CR \longrightarrow CR \longrightarrow CR \longrightarrow CR \longrightarrow CH_2NO_2 \longrightarrow RCOCCl \longrightarrow NOH$

It will be recalled that the reaction product of the vapor phase nitration of acetone gave no nitroacetone ethylene acetal.

Sodium salts of the four nitro ketones and also of 1-bromo-1-nitroacetone, 1-bromo-1-nitro-2-butanone, and nitroacetone ethylene acetal were all prepared and from them the bromo derivatives were made. To obtain acceptable yields from nitroacetone it was found necessary to add the dry salt to the bromine (in carbon tetrachloride) and not vice versa, otherwise there was extensive cleavage with formation of bromonitromethane. The brominated nitro ketones underwent hydrolytic cleavage with ease. Thus, during steam-distillation of 1-bromo-1nitroacetone or 1,1-dibromo-1-nitroacetone there was breakdown to bromonitromethane and dibromonitromethane, respectively. Bromonitromethane was the only product found by Wieland and Bloch (5) when ammonium aci-nitroacetone was treated with bromine water. The bromo nitro compounds obtained in this study were all liquids, skin irritants, and lachrymators.

Analysis of the bromo nitro compounds revealed a little too much bromine in many instances. Two explanations seem reasonable: (a) the presence of small amounts of bromonitroalkane, or (b) the presence of a little dibrominated material along with the mono.

Attempts were made to synthesize pyruvic aldehyde by acidifying an aqueous solution of sodium *aci*-nitroacetone, but none was obtained. Similarly, no aldehyde was formed from 1-nitro-2-butanone or its ethylene acetal. Instead, much of the original nitro compounds were regenerated. The nitroacetone which was

obtained in this way was readily characterized, for example, as the 2,4-dinitrophenylhydrazone. The fact that no such derivative was obtainable from the sodium salt of the reaction product of the vapor phase nitration of acetone casts doubt on the presence of much sodium *aci*-nitroacetone in the sodium salt.

EXPERIMENTAL

The nitro alcohols. The following general procedure, a modification of Staub's method (11) which he developed for the synthesis of 1-nitro-2-propanol in 52% yield, was used for all four alcohols.

To a stirred mixture of 3 moles of nitroalkane (note 1) and 120 ml. of water was added dropwise (note 2) a solution of 3 moles of aldehyde (CH₁CHO, C₂H₅CHO) and 155 ml. of water during 90 minutes. Small portions of solid sodium carbonate were added from time to time to keep the mixture basic to litmus (note 3). Stirring was maintained for 2 hours after aldehyde was all added, then the mixture was let stand for 3 hours, ether extracted, and the ether extract was washed and dried (Na₂SO₄). The ether was removed and the nitro alcohol was twice vacuum distilled. Results are collected in Table II.

Note 1. Three-molar quantities were taken with nitromethane but only one-molar with nitroethane. Note 2. The aldehyde could be added all at once except in the preparation of 1-nitro-2-propanol. Note 3. The temperature rise was greatest in the preparation of 1-nitro-2-propanol, gradually reaching 60° even with the incremental addition of aldehyde. This reaction mixture alone of the four nitro alcohols prepared became homogeneous as the reaction progressed.

The nitro ketones. The procedure used by Levy and Scaife (1) for the oxidation of 1-nitro-2-propanol was followed for the preparation of the four nitro ketones, using larger quantities and a longer period of time for the addition of the acid. Nitroacetone crystallized out of the reaction mixture and could be separated by filtration. The other ketones were liquids and were removed from the reaction mixture by extraction with ether followed by distillation. The detailed procedure used for nitroacetone is given below; the preparation of the other nitro ketones was similar.

Nitroacetone: A mixture of 100 g. of 1-nitro-2-propanol, 150 g. of sodium dichromate, and 100 ml. of water was placed in a 1-liter, 3-necked flask equipped with a mechanical stirrer and a thermometer. A cooled solution of 98 ml. of concentrated sulfuric acid in 46 ml. of water was added dropwise during 6 hours. The temperature was kept between $10-20^{\circ}$ by external ice cooling. Stirring was continued for two hours after the addition was completed. Then 300 ml. of water was added and the mixture was filtered. The product was washed with small portions of ice-water and dried in the air. The yield of crude, pale green crystals melting at $42-43^{\circ}$ was 65 g. or 66%. Recrystallization from 40 ml. of methanol gave 44 g. melting at $45-46^{\circ}$. An additional recrystallization from ethyl acetate raised the melting point to 47° . Ether extraction of the filtrate, drying, and chilling of the residual dark oil at 0° for several hours resulted in another 2 g. of crystals, but the filtrate decomposed on standing at 0° .

If a reaction temperature of 40° was used (instead of 10-20°) the product then was an

Nitroalkane	Alcohol	в.:	Vield. %		
TTTTO MARKANC		°C.	mm.		
CH ₂ NO ₂	1-nitro-2-propanol	86-89	8	70	
CH ₃ NO ₂	1-nitro-2-butanol	98-99	9	67	
$C_2H_5NO_2$	3-nitro-2-butanol	8087	8	65	
$C_2H_5NO_2\dots\dots$	2-nitro-3-pentanol	9096	8	61	

TABLE II PREPARATION OF NITRO ALCOHOLS

uncrystallizable yellow oil which is probably the substance reported by Henry (1) to be nitroacetone.

Other ketones prepared by the above method:

1-Nitro-2-butanone, b.p. 92-100° (8 mm.), 67% yield. Redistillation yielded a central cut at 118° (28 mm.), d_{20}^{20} 1.156, n_{2}^{20} 1.4410, m.p. 12-15°.

Anal. Calc'd for C4H7NOs: C, 41.02; H, 6.03; N, 11.96.

Found: C, 41.03; H, 6.01; N, 12.34.

3-Nitro-2-butanone, b.p. 71-75° (9 mm.), 80% yield. Redistillation at 25 mm. gave a middle fraction at 92° of practically colorless liquid, d_{20}^{20} 1.156, n_{p}^{20} 1.4349. It failed to solidify in icesalt.

Anal. Cale'd for C4H7NO3: C, 41.02; H, 6.03; N, 11.96.

Found: C, 41.63; H, 6.43; N, 12.13.

2-Nitro-3-pentanone, b.p. 82-85° (8 mm.), 74% yield. The b.p. at 28 mm. was 108° ; d_{20}^{20} 1.115, n_2^{20} 1.4378. It remained liquid at -20° .

Anal. Calc'd for C₅H₉NO₃: C, 45.79; H, 6.92; N, 10.68.

Found: C, 46.04; H, 7.05; N, 10.84.

Properties of nitroacetone. As stated above, this colorless solid melted at 47°. Its boiling point was 81-82° at 8 mm. Its semicarbazone melted at 164-165° (dec.) after 2 crystallizations from 95% alcohol, comparing with 163-164° listed by Harries (9).

Nitroacetone was fairly unstable and it decomposed unpredictably. One portion was kept at 15° in a desiccator over potassium hydroxide, as suggested by Levy and Scaife (1), for over two months with only a slight browning. Another portion, recrystallized similarly from methyl alcohol, which was kept in the same desiccator decomposed after two weeks, blowing off the cork, filling the desiccator with white fumes, and leaving a sticky, dark brown liquid. When the crude product obtained from the oxidation was left at room temperature overnight instead of being recrystallized at once, it decomposed leaving nothing but a carbonaceous mass. The most satisfactory method of keeping nitroacetone was found to be in ether solution. The ether was removed by evaporation under reduced pressure when the nitroacetone was needed. Nitroacetone kept at room temperature in this way showed only a small amount of discoloration after three months, while another portion was kept at 5° for over a year without excessive decomposition.

2,4-Dinitrophenylhydrazones. These new derivatives of the four nitro ketones were prepared by refluxing a mixture of 0.5 g. of the ketone, 0.4 g. of 2,4-dinitrophenylhydrazine in 25 ml. of alcohol, and 0.5 ml. of conc'd hydrochloric acid for ten minutes, cooling, collecting the precipitate, and crystallizing it twice or thrice from either absolute ethanol or a mixture of 95% alcohol and ethyl acetate. Results are given in Table III.

Anils. N-Nitroisopropylideneaniline. Harries' directions (9) were followed, using aniline and 50% acetic acid with nitroacetone, but the compound melted at 79° after three crystallizations from absolute alcohol and one from ligroin, instead of 87°.

N-(1-Nitromethyl propylidene) aniline, $O_2NCH_2C(C_2H_5)$ = NC_6H_5 . 1-Nitro-2-butanone (0.6 g.), aniline (0.6 g.), and glacial acetic acid (3 ml.) were mixed and warmed at 100° for 3 minutes. (If 50% acetic acid was used or if a longer heating period was used only dark oils

Compound	mp °C	Formula	Nitrogen Analysis		
Compound	ш.р., с.	T OIMUIA	Calc'd	Found	
Nitroacetone 1-Nitro-2-butanone 3-Nitro-2-butanone 2-Nitro-3-pentanone	139–140 107–109 124–125 105–106	$\begin{array}{c} C_{9}H_{9}N_{5}O_{6}\\ C_{10}H_{11}N_{5}O_{6}\\ C_{10}H_{11}N_{5}O_{6}\\ C_{11}H_{13}N_{5}O_{6}\end{array}$	$24.7 \\ 23.6 \\ 23.6 \\ 22.5$	24.6 23.8 23.3 22.5	

TABLE III

were obtained.) Two drops of the mixture then were mixed with 2 drops of water to obtain an oil which slowly crystallized as it was scratched with a glass rod at 0°. Then, the rest of the reaction mixture was diluted with 20 ml. of water cooled in an ice-bath, and inoculated with the seed crystals to yield ultimately 0.55 g. (56% yield) of crude solid, m.p. 40-43°. Recrystallization from benzene-ligroin gave pale yellow needles, m.p. 47°.

Anal. Calc'd for C₁₀H₁₂N₂O₂: C, 62.48; H, 6.29.

Found: C, 62.92; H, 6.42.

N-(2-Nitro-1-methylpropylidene)aniline. This anil was prepared similarly from 3-nitro-2butanone except that the period of heating was one minute. The yield of first crystals was 50%, m.p. 97-100°. Recrystallization from benzene-ligroin gave thin yellow platelets, m.p. 102°.

Anal. Calc'd for C₁₀H₁₂N₂O₂: C, 62.48; H, 6.29.

Found: C, 62.61; H, 6.29.

N-(2-Nitro-1-ethylpropylidene)aniline. This was prepared similarly from 2-nitro-3pentanone, but the heating period was 12 minutes and the original crystallization was with more difficulty: crude yield, 60%; m.p. 70-73°. After recrystallization from benzene-ligroin the thin yellow platelets melted at 81-82°. Longer or shorter periods of heating resulted in much lower yields.

Anal. Calc'd for C₁₁H₁₄N₂O₂: C, 64.06; H, 6.84.

Found: C, 64.60; H, 6.98.

3-Nitro-1-benzylideneacetone. Harries' directions (9) were followed using equal weights of nitroacetone and benzaldehyde in 10 volumes of 5% sodium hydroxide solution, but instead of duplicating Harries' m.p. of 87-88° (after sintering at 83°) our value of 82-83° was close to that of Wieland and Blümich (12) who made the compound differently and reported m.p. 84°.

We found that attempted substitution of alcoholic sodium methoxide solution gave only a trace of this product. Also, amines (butylamine or piperidine with no added solvent) gave no crystals at all.

When benzaldehyde and aqueous sodium hydroxide (5 to 20%) were treated with the nitrobutanones or with 2-nitro-3-pentanone no products were obtained other than dark tarry oils.

Evidence supporting the structure of 3-nitro-1-benzylideneacetone is its oxidation to benzoic acid without forming acetic acid. It yielded no iodoform with sodium hypoiodite, and it did not decolorize bromine in carbon tetrachloride.

The cyclic ethylene acetals. The general method of synthesis was to reflux 0.2 mole of the nitro ketone, 0.21 mole of ethylene glycol, 0.5 g. of *p*-toluenesulfonic acid, and 100 ml. of benzene, using an apparatus similar to that described by Salmi (13) to remove water as

	Dura- tion of reflux- ing	Yield, %	b.p.		$n_{\rm D}^{20}$	d ²⁰ 20		Analysis			
Name							Formula	Calc'd		Found	
	hrs.		°C.	mm				СН		С	н
Nitroacetone ethylene acetal	6	74	116	19	1.4464	1.242	C₅H₃NO₄	40.81	6.16	40.87	6.18
1-Nitro-2-butanone ethylene acetal	15 40	59 0	108	8	1.4480	1.175	$C_6H_{11}NO_4$	44.71	6.88	44.81	6.99
3-Nitro-2-butanone ethylene acetal	72 5	36 16	105– 106	7	1.4478	1.185	$C_6H_{11}NO_4$	44.71	6.88	45.54	6.73
2-Nitro-3-pentanone ethylene acetal	48	39	112– 113	8	1.4490	1.136	$C_7H_{13}NO_4$	47.99	7.48	47.66	7.81

TABLE IV The Cyclic Acetals

formed. The duration of refluxing was found to be critical. Much lower yields of nitroacetone ethylene acetal were found after 16 hours of refluxing than after 6 hours. To isolate the acetals, solvent benzene was distilled off and the residue was vacuum-distilled. Glycol and some unreacted ketone came over first, then the desired cyclic acetal. In all distillations, unless the flask was cooled before opening it to air, the residue decomposed with an evolution of brown fumes and left a carbonaceous mass. Details are given in Table IV.

Attempted hydrolysis. After 6 hours of heating at 100° a mixture of 2.5 g. of nitroacetone ethylene acetal and 25 ml. of 0.1 M sulfuric acid only a trace of nitroacetone (m.p. 40-44°) was obtained by ether extraction.

Similar treatment of 2.5 g. of 1-nitro-2-butanone ethylene acetal with either 0.1 M or 60% sulfuric acid yielded 1.3 g. of ether extract with the same b.p. and $n_{\rm D}$ as the original acetal; but the first drops of distillate did yield a small amount of precipitate with 2,4-dinitrophenylhydrazine indicating that a little ketone had been formed.

Similarly, the ethylene acetals of 3-nitro-2-butanone and 2-nitro-3-pentanone gave traces only of the ketones on warming with 0.1 M sulfuric acid.

Sodium salts. A solution of the nitro compound in 6 volumes of 1:1 alcohol-ether or 10-20 volumes of ether was added slowly with stirring into an alcoholic solution containing the calculated amount of sodium ethoxide. The precipitated salt was collected, washed with ether, air-dried, and then kept in a desiccator. The last amounts of ether were difficult to remove, which may account for the low analysis with sodium *aci*-nitroacetone. Sodium bromo-*aci*-nitroacetone was yellow as first formed and it turned orange on standing in air.

Anal. of Na derivatives: from nitroacetone, Calc'd for Na, 18.4; Found: 17.6, 17.7. From 1-bromo-1-nitroacetone, Calc'd: 11.3; Found: 11.3. From nitroacetone ethylene acetal, Calc'd: 13.6; Found: 13.4. From 1-nitro-2-butanone, Calc'd: 16.5; Found: 16.2. From 3nitro-2-butanone, Calc'd: 16.5; Found: 16.3. From 2-nitro-3-pentanone, Calc'd: 15.0; Found: 14.9.

Sodium 1-bromo-aci-1-nitro-2-butanone was prepared also (for bromination, below) but it was not analyzed. It required 500 ml. of ether to precipitate the salt from 10 g. of nitro ketone.

Bromination. The solid sodium salts, obtained as indicated above, were added in small portions to a 0.9-molar portion (based on the nitro ketone taken) of bromine in carbon tetrachloride cooled in an ice-bath. The mixture was stirred for 15 minutes, then after filtering off the sodium bromide dry air was bubbled through the filtrate to remove

Compound	b.p. °C.	mm	n _D ²⁰	d 2 0 2 0	Yield,	Formula	Analysis Bromine			
							Calc'd	Found		
1-Bromo-1-nitroacetone	86-88	10	1.4903	1.817	80	C3H4BrNO3	43.9	$\begin{array}{c} 46.4\\ 45.2 \end{array}$		
1,1-Dibromo-1-nitroacetone ^a	93-97	14	1.5195	2.115	52	C ₃ H ₃ Br ₂ NO ₃	61.3	60.9		
1-Bromo-1-nitroacetone ethylene acetal ^b	126–128	25	1.4800	1.688	22	C5H8BrNO4	35.4	35.2		
1-Bromo-1-nitro-2-butanone	112-116	25	1.4830	1.483	64	C4H6BrNO2	40.8	$\begin{array}{c} 43.3\\ 43.5\end{array}$		
1,1-Dibromo-1-nitro-2- butanone ^a	105–108	28	1.5150	2.003	9	$C_4H_5Br_2NO_3$	58.1	59.6		
3-Bromo-3-nitro-2-butanone	80-82	26	1.4749	1.634	65	C4H6BrNO2	40.8	43.1		
2-Bromo-2-nitro-3-pentanone	97-98	27	1.4722	1.536	74	C5H8BrNO3	38.1	38.7		

TABLE V

THE BROMO COMPOUNDS

^a Prepared from the monobromo compound.

^b Prepared from nitroacetone ethylene acetal.

excess bromine. The bromo nitro compounds were purified by distillation (see Table V). These were lachrymatory liquids and very irritating to the skin. 1,1-Dibromo-1-nitroacetone solidified on chilling, and melted at 18.5-19°. In one preparation of 3-bromo-3nitro-2-butanone the liquid decomposed during distillation, but other runs distilled satisfactorily. Analysis showed that some of the monobromo compounds contained a little dibromo compound as impurity, which was difficult to remove by distillation.

Hydrolytic cleavage. A mixture of 1-bromo-1-nitroacetone (2.5 g.) and water (30 g.) was distilled to obtain 20 ml. of distillate which was extracted with ether. The ether portion contained bromonitromethane, and 1.6 g. (83%) of this was collected at 40-52° (16 mm.); redistillation, b.p. 145-147° (750 mm.), n_p^{20} 1.4880. A synthetic sample prepared by Scholl's method (14) boiled at 146-148° (750 mm.) or 51° (14 mm.); n_p^{20} 1.4901; d_2^{20} 2.007.

The aqueous portion was neutralized (NaOH) and evaporated to dryness, giving 0.8 g. (71%) of sodium acetate; p-toluidide, m.p. 146-147°.

When 1.5 g. of 1,1-dibromo-1-nitroacetone was distilled with water 0.4 g. (32%) of dibromonitromethane, b.p. 56-60° (15 mm.), n_{ν}^{20} 1.5214, was obtained. Dibromonitromethane, prepared for comparison, boiled at 56-58° (12 mm.), n_{ν}^{20} 1.5358, d_{ν}^{20} 2.475. In the literature (14) these boiling points are listed: 58-60° (13 mm.), 52° (16 mm.).

The hydroximyl chlorides. From nitroacetone. Nitroacetone (20 g.) dissolved slowly in 45 ml. of conc'd hydrochloric acid. Colorless crystals began to appear after 4 hours, and after 24 hours they were collected; yield, 13.8 g. Another 8.0 g. was ether-extracted from the filtrate: total yield, 21.8 g. or 93%. This pyruvohydroximyl chloride was recrystallized both from carbon tetrachloride and ligroin; m.p. 106–108°, with a tendency to sublime. The compound has been made previously (15) from pyruvonitrolic acid.

We also made the compound in high yield by passing hydrogen chloride gas into an ether solution of nitroacetone, then leaving the solution 4 days before processing.

Derivatives. Pyruvohydroximyl chloride oxime (15, 16), m.p. 182-183°.

Pyruvohydroximic anilide (16), m.p. 119-120°.

Pyruvohydroximyl chloride semicarbazone is reported (16) to melt at 158°. This probably is a typographical error since, by following the directions given, we found the m.p. to be 198° dec.

A new derivative pyruvohydroximic o-toluidide, $CH_{3}COC(=NOH)NHC_{6}H_{4}CH_{4}$, was prepared in 95% yield by leaving a mixture of 1.2 g. of pyruvohydroximyl chloride, 20 ml. of ether, and 2.1 g. of o-toluidine at 25° for 24 hours, then evaporating, washing with water, and crystallizing from alcohol-water or benzene-ligroin. Yield, 1.8 g.; m.p. 84–85°.

Anal. Calc'd for C₁₀H₁₂N₂O₂: C, 62.48; H, 6.29.

Found: C, 62.67; H, 6.19.

From 1-nitro-2-butanone. A mixture of 13 g. of this nitro ketone and 30 ml. of conc'd hydrochloric acid was shaken occasionally during 20 hours, then was cooled and filtered to yield 9.4 g. of white solid. Another 5 ml. of hydrochloric acid was added to the filtrate and, after 15 hours, another 1.5 g. of solid resulted; total yield, 73%. It was recrystallized from either carbon tetrachloride or ligroin; m.p. $80-81^{\circ}$.

Anal. Calc'd for C₄H₆ClNO₂: Cl, 26.15. Found: Cl, 26.20.

An alternative synthesis, giving a 97% yield, was achieved by passing hydrogen chloride into 10 g. of the nitro ketone and 80 ml. of ether. Methylpyruvohydroximyl chloride irritates the skin and causes blisters which are slow to heal.

Methylpyruvohydroximic anilide. This derivative was prepared from the chloride (1.35 g.)and aniline (1.86 g.) in 10 ml. of ether adapting the directions given above for the *o*-toluidide, yield 1.0 g. or 59%. Crystallization from alcohol-water or benzene-ligroin gave pale yellow prisms melting at 87°.

Anal. Calc'd for C10H12N2O2: C, 62.48; H, 6.29.

Found: C, 62.69; H, 6.39.

The hydrochloride of this anilide, m.p. 105–115° d., separated gradually from an ether solution containing the anilide and hydrogen chloride. Yield, 0.3 g. from 0.4 g. of the anilide. Water changed it back to the anilide.

From the ethylene acetals. Nitroacetone ethylene acetal or 1-nitro-2-butanone ethylene

acetal (5 g.) was mixed with 20-30 ml. of concentrated hydrochloric acid. Crystals formed on standing 5 to 10 hours. These were collected on a filter, and the filtrate was extracted with ether to obtain more of the same compound. The ether extract was dried with calcium chloride before removal of the solvent. The total solid product was crystallized from carbon tetrachloride giving pyruvohydroximyl chloride and methylpyruvohydroximyl chloride, respectively. Mixture m.p. determinations with authentic specimens showed no lowering of melting points.

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SUMMARY

Vapor phase nitration of acetone at 300° yields an unstable reaction product, apparently not nitroacetone but not characterized as yet. It gave none of the ketone reactions and possessed a molecular weight about twice that expected for nitroacetone.

Nitroacetone, 1-nitro-2-butanone, 3-nitro-2-butanone, and 2-nitro-3-pentanone were synthesized by oxidation of the corresponding alcohols. The first two of these nitro ketones reacted with hydrogen chloride to yield hydroximyl chlorides. All of the ketones formed cyclic acetals on reaction with ethylene glycol.

Sodium salts of the nitro ketones were prepared and from them the bromo nitroketones.

Other derivatives, reactions, and properties of these nitro ketones are reported.

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