to be less stable than I due to eclipsing interactions[6] and the necessity for a larger part of the molecule to be close to the catalyst surface. The latter factor will decrease the probability of chemisorption to form II or III and will cause these configurations to be more rigid than I. Additional information will be necessary before the importance of these and other factors which may influence the course of this reaction can be determined. In agreement with these considerations is the observation that thoria, but not alumina, catalyzes the dehydration of 2-octanol much more rapidly than 3- or 4-octanol.

Acknowledgment.—We thank Dr. C. M. Starks for helpful discussions.

(6) These eclipsing interactions alone are not sufficiently large to explain the observed results. Similar interactions are present in the transition states of amine oxide and acetate pyrolysis which give nearly statistical product distributions. See C. H. DePuy and R. W. King, *Chem. Rev.*, **60**, 431 (1960).

RESEARCH AND DEVELOPMENT DEPARTMENT
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RECEIVED MAY 27, 1963

Acetone as a Nucleophile

Sir:

In a recent communication[1] the intervention of dioxane as a nucleophilic agent in the hydrolysis of optically active 2-octyl brosylate in aqueous dioxane was suggested as an explanation for the observed ability of added azide ion to increase the optical purity of the inverted product alcohol from 77% in the absence of sodium azide to 100% in its presence. It was suggested that azide ion may accomplish this effect by its selective attack on the pre-formed oxonium ion intermediate, thus preventing the formation of alcohol *via* this racemizing route. These results led us to search for similar phenomena in other mixed solvents containing "inert" components. This communication reports evidence for a parallel involvement of acetone in solvolysis reactions of the 2-octyl brosylate system.

Solvolysis of 2-octyl brosylate in 80% methanolic acetone furnished, in addition to the expected 2-octyl methyl ether, 2-octanol.[2] By vapor phase chromatography the alcohol was determined to constitute 15 ± 5% of the solvolysis mixture. Control experiments established that neither adventitious water nor water formed in condensation reactions of the solvent is able to account for the formation of alcohol.

The formation of alcohol under these conditions would seem to implicate acetone as an effective nucleophile, the mixed methyl 2-octyl ketal of acetone serving as an intermediate
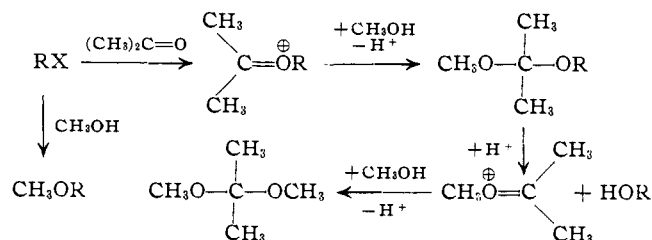
Confirmation of the suggested scheme has come from the following experiments. (1) When solvolysis was conducted in the same solvent system in the presence of a slight excess of 2,6-lutidine, no 2-octanol was detected by v.p.c. Under these buffered conditions the mixed ketal is presumably stable. However, neutral-

(1) H. Weiner and R. A. Sneen, *J. Am. Chem. Soc.*, **84**, 3599 (1962).
(2) Isolated by preparative v.p.c.; identity established by microanalysis and infrared spectrum.

ization of this reaction mixture with *p*-toluenesulfonic acid resulted in the formation of 2-octanol (by v.p.c.). (2) Although attempts to isolate the mixed ketal in a pure state have not as yet been successful, a precursor of acetone has been shown to be present among the products of a basic solvolysis (lutidine). Thus when the reaction mixture was concentrated by distillation and diluted with ether to precipitate the amine salts, a residue was obtained whose infrared spectrum was transparent in the carbonyl region. However, when this residue was treated with acidic 2,4-dinitrophenylhydrazine reagent, a solid, identified as the 2,4-dinitrophenylhydrazone of acetone, was formed.

The technique described above for detecting the nucleophilic intervention of acetone in solvolyses conducted in methanolic acetone is, of course, not applicable to solvolyses in aqueous acetone where one might also expect the phenomenon to occur. It is interesting in this connection, however, that solvolysis of 2-octyl brosylate in 80% aqueous acetone gave rise to 2-octanol, formed with 99 ± 2% inversion of configuration. Thus acetone, if it intervenes in this aqueous system, does so with essentially complete inversion of configuration.

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(3) Predoctoral Fellow of the National Institutes of Health.
(4) Correspondence should be addressed to this author.

DEPARTMENT OF CHEMISTRY   HENRY WEINER[3]
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LAFAYETTE, INDIANA
RECEIVED APRIL 27, 1963

A Novel Rearrangement of Cyclic α-Nitro Ketones

Sir:

A recent communication of the rearrangement of 3-nitrocamphor[1] prompts us to report our independent findings which indicate that sterioidal α-nitro ketones undergo this novel type of rearrangement to N-hydroxy imides under acid conditions.

16-Nitro-5-androsten-3β-ol-17-one (I), m.p. 105–107°, prepared from 5-androsten-3β-ol-17-one by base-catalyzed condensation with butyl nitrate and consisting of a 1:1 mixture of 16α and 16β epimers (by n.m.r.), is converted by treatment with acid in 75% yield to the N-hydroxyimide II, m.p. 260–263°, or by treatment with acetic anhydride at room temperature in 80% yield to the corresponding diacetate III, m.p. 231–232°.[2] With hydrochloric acid in acetic acid, I or its potassium salt is converted in 75% yield to 3β-acetoxy-16,17-seco-5-androstene-16,17-dioic N-hydroxyimide (IV), m.p. 241–245°, which is acetylated quantitatively to III. N-Hydroxyimide IV is also obtained in 75% yield by reaction of anhydride VII with hydroxylamine. Hydrolysis of diacetate III with potassium hydroxide at room temperature leads to hydroxyimide II; with potassium *t*-butoxide III is converted to 3β-hydroxy-16,17-seco-5-androstene-16,17-dioic acid. N-Hydroxyimides II and IV yield corresponding N-methoxy derivatives V (95%), m.p. 214–215°, and VI (85%), m.p. 186–188°, respectively. V and VI are interconvertible by acetylation and hydrolysis.
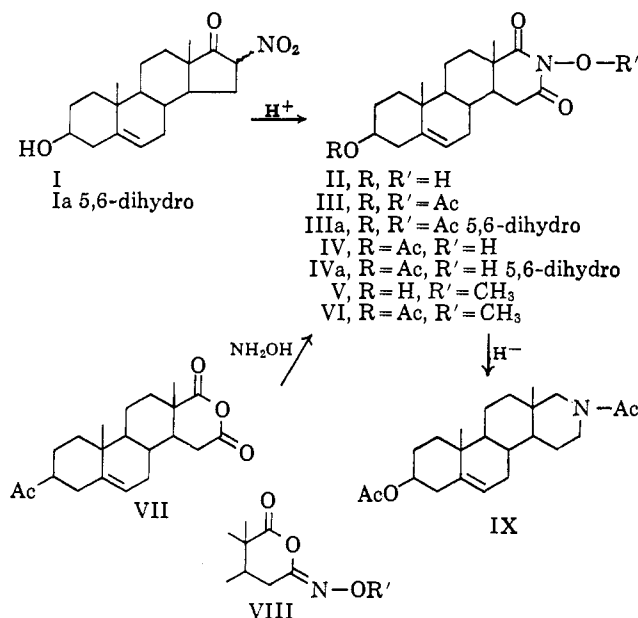
Analogous results can be achieved in the 5,6-dihydro series: Ia, m.p. 180–182°, 95%; IIIa, m.p. 180–182°, 80%; IVa, m.p. 224–226°, 80%. Other examples of this rearrangement are provided by the formation in 75% yield of N-acetoxy-2,3-secocholestane-2,3-dioic

(1) H. O. Larson and E. K. W. Wat, *J. Am. Chem. Soc.*, **85**, 827 (1963).
(2) Satisfactory analyses were obtained for all compounds for which melting points are given.

I
Ia 5,6-dihydro

II, R, R' = H
III, R, R' = Ac
IIIa, R, R' = Ac 5,6-dihydro
IV, R = Ac, R' = H
IVa, R = Ac, R' = H 5,6-dihydro
V, R = H, R' = CH₃
VI, R = Ac, R' = CH₃

VII

VIII

IX

acid imide, m.p. 205–207° dec., from 2-nitrocholestanone, m.p. 135–136°, or from its potassium salt upon treatment with acetic anhydride or upon treatment first with hydrochloric acid followed by acetylation of the intermediate N-hydroxyimide, m.p. 184–188°. We also confirm the results of Lowry[3] and of Larson and Wat[1] for the isolation of N-hydroxycamphorimide from the rearrangement of α-nitrocamphor or from the reaction of camphoric anhydride with hydroxylamine.

The structure assignment of an N-hydroxyimide (cf. II–IV) rather than an isomeric anhydride oxime (cf. VIII) to the products described above is based on infrared spectra and chemical transformations. The infrared spectra (in KBr) of our steroidal N-hydroxyimides as well as of N-hydroxycamphorimide show strong absorption at 3250–3300 cm.⁻¹ (OH), 1720–1730 cm.⁻¹ and 1675–1690 cm.⁻¹ (imide carbonyls); anhydride oximes of type VIII have been shown[4] to absorb strongly above 1800 cm.⁻¹. The N-acetoxyimides (i.e., III and IV) show strong absorption at 1800 cm.⁻¹ (acetate carbonyl attached to strong electron withdrawing groups),[5] 1720 and 1700 cm.⁻¹ (imide carbonyl).

3β,N-Dihydroxy-16,17-seco-5-androstene-16,17-di ic imide (II) is stable to acid hydrolysis even in the presence of levulinic acid. This and the other chemical properties of these compounds indicate a structure such as II rather than one of type VIII. Further evidence of the piperidine skeleton is supplied by lithium aluminum hydride–aluminum chloride reduction of III followed by acetylation to the known[6] 3β-acetoxy-N-acetyl-D-homo-17-aza-5-androstene (IX), m.p. 210–212°.

Two major paths may be considered to explain the rearrangement of these α-nitroketones to N-hydroxy- or N-acetoxyimides.[7] The mechanism proposed by Larson and Wat[1] involving protonation of the carbonyl and multiply-charged intermediates is unlikely and not applicable to the rearrangement proceeding in acetic anhydride. That the aci form of the nitro compound (cf. X) may be involved is suggested by the fact that

(3) T. M. Lowry, J. Chem. Soc., **73**, 986 (1898); ibid., **83**, 953 (1903).
(4) L. A. Carpino, J. Am. Chem. Soc., **79**, 98 (1957); D. E. Ames and T. F. Grey, J. Chem. Soc., 631, 3518 (1955); ibid., 2310 (1959).
(5) A. Hassner and I. H. Pomerantz, J. Org. Chem., **27**, 1760 (1962).
(6) B. M. Regan and F. N. Hayes, J. Am. Chem. Soc., **78**, 639 (1956).
(7) A third path, analogous to the acid-promoted rearrangement of primary nitroalkanes to hydroxamic acids [H. L. Yale, Chem. Rev., **33**, 209 (1943)] except involving a cleavage reaction, may also be considered.

even the salt of the nitroketone reacts with acetic anhydride and from the fact that 2-nitroindanone, which is known[8] to enolize to 1-hydroxy-2-nitroindene rather than to an aci form such as X, does not undergo rearrangement under acid conditions. Path (a) represents a Beckmann rearrangement of an aci form of a nitro compound analogous to that of a conventional oxime. Path (b) represents a cleavage reaction and is analogous to the cleavage of cyclic α-oximino ketones or

X, R = H or Ac

(a)

II or IV

(OH₂)
(Ac₂O)

X

(b)

XI
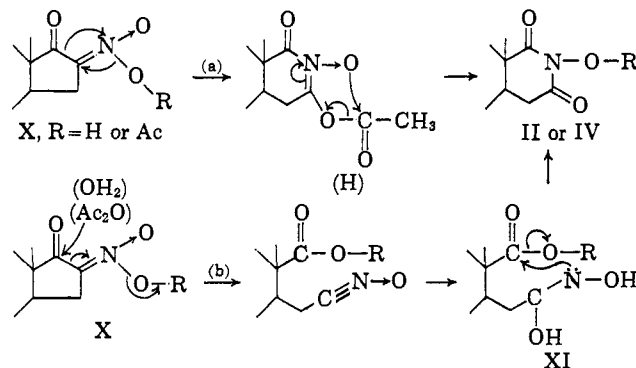
of their acetates to nitrile acids followed by ring closure to an imide[5,9]; it is also analogous to an acid-catalyzed rearrangement of a nitro compound reported by Noland and co-workers.[10] Path (b) involves a hydroxamic acid intermediate (cf. XI) and might be applicable even if the reaction proceeded first to VIII and thence to II. Hydroxamic acid XI is also the most likely intermediate in the formation of these N-hydroxyimides from cyclic anhydrides and hydroxylamine. Experiments to elucidate the mechanism are in progress.

(8) R. D. Campbell and C. L. Pitzer, J. Org. Chem., **24**, 1531 (1959).
(9) A. Hassner, W. A. Wentworth and I. H. Pomerantz, ibid., **28**, 304 (1963).
(10) W. E. Noland, J. H. Cooley and P. A. McVeigh, J. Am. Chem. Soc., **81**, 1209 (1959).

DEPARTMENT OF CHEMISTRY ALFRED HASSNER
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Conversion of a Semicarbazone to a Carbamate. A Novel Rearrangement

Sir:

We wish to report a new reaction of a semicarbazone. When benzophenone 4,4-diethylsemicarbazone, I, is treated with lead tetraacetate there is obtained a 63% yield of 2-oxo-1,1-diphenylpropyl diethylcarbamate, II.

$$(C_6H_5)_2C=N-NH-CO-N(C_2H_5)_2 \xrightarrow{LTA}$$

I

$$(C_6H_5)_2C-O-CO-N(C_2H_5)_2$$
$$| $$
$$CO$$
$$|$$
$$CH_3 \quad II$$
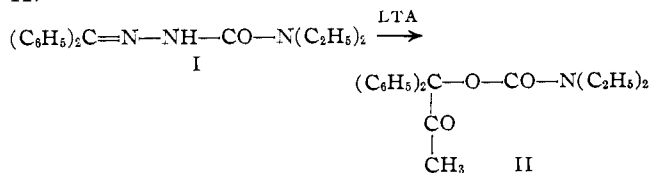
This reaction is in contrast to the behavior of ketohydrazones, which with lead tetraacetate form azoacetates in 55 to 90% yields.[1] The addition of 0.03 mole of I, m.p. 100–101° (Anal.[2] Calcd. for C₁₈H₂₁N₃O: N, 14.23. Found: N, 14.32) to lead tetraacetate (0.032 mole) at 0–5° in methylene chloride solution according

(1) D. C. Iffland, L. Salisbury and W. R. Schafer, J. Am. Chem. Soc., **83**, 747 (1961).
(2) All elemental analyses were performed by Galbraith Laboratories, Knoxville, Tennessee.