and 5-nitro-2-thenaldehyde thiosemicarbazone.[2] Since no derivatives of 4-nitro-2-thenaldehyde or 4-nitro-2-furaldehyde have been reported, a synthesis of these compounds was attempted by direct nitration of the unprotected aldehydes, in analogy to the formation of *m*-nitrobenzaldehyde[3] by nitration. Furthermore, no methods of synthesis of these compounds have been described previously, although Gever[4] recently isolated 4-nitro-2-thenaldehyde as a by-product in the preparation of 5-nitro-2-thenaldehyde diacetate.

The nitration was carried out in a somewhat different fashion from that described for *m*-nitrobenzaldehyde[3] by dissolving the aldehyde in concentrated sulfuric acid, cooling to −10° by the addition of carbon dioxide snow, and adding the nitrating solution slowly at the stated temperature. A yield of 64.5% of pure 4-nitro-2-thenaldehyde was obtained after fractionation of the product, but no aldehyde could be detected in the dark solution resulting from the nitration of 2-furaldehyde, either by reaction with 2,4-dinitrophenylhydrazine or by distillation. When this procedure was carried out with benzaldehyde, however, a yield of 90% of purified *m*-nitrobenzaldehyde, was obtained—an improvement over the 75–84% yields which have been reported.[3]

The nitration of a 2-substituted thiophene in the 4-position is an exception to the previous findings that substitution predominates in the 5-position regardless of the type of director present in the 2-position.[5] In addition no evidence of 5-nitro-2-thenaldehyde could be detected in the product.

Experimental

4-Nitro-2-thenaldehyde.—To a beaker containing 21.2 g. (0.22 mole) of concentrated sulfuric acid cooled to −10° by means of carbon dioxide snow and surrounded by an ice-bath was added slowly 8.7 g. (0.08 mole) of 2-thenaldehyde (prepared by the Sommelet method[6]). Stirring was employed throughout the reaction, and the temperature was held at −10° by the addition of more Dry Ice as needed. After complete addition of the aldehyde, a nitrating solution of previously cooled fuming nitric acid (18.9 g., 0.30 mole) and concentrated sulfuric acid (14.1 g., 0.14 mole) was likewise slowly introduced. The addition consumed two hours, and the reaction mixture was stirred for another half-hour at the same temperature, after which it was allowed to warm gradually to 0°. The reaction mixture was then poured into 300 g. of a cracked ice-water mixture, stirred for several minutes, and extracted with two 200-cc. portions of diethyl ether. The ether solution was dried over sodium sulfate and evaporated to approximately 30 cc. over a steam-bath, after which it was fractionally distilled under reduced pressure. The fraction boiling at 126–131° at 3 mm. was collected, and 7.9 g. (64.5%) of yellow crystals, m.p. 35–37°, solidified in the receiver.

The semicarbazone, a yellow solid, melted[7] at 234–236°; Gever[4] reported melting points of 36–37° for the nitroaldehyde and 234–235° for the semicarbazone.

The 2,4-dinitrophenylhydrazone, an orange solid, melted at 290–294°.

Anal.[8] Calcd. for $C_{11}H_7N_5O_6S$: C, 39.16; H, 2.09. Found: C, 38.61; H, 2.24.

The phenylhydrazone, golden platelets, melted at 192–194°.

Anal. Calcd. for $C_{11}H_9N_3O_2S$: C, 53.42; H, 3.67. Found: C, 53.76; H, 3.79.

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[2] S. A. Minton, J. E. Officer and R. L. Thompson, *J. Immunol.*, **70**, 222 (1953).

[3] C. Bertagnini, *Ann.*, **79**, 260 (1851); O. Widman, *Ber.*, **13**, 678 (1880); D. W. Bissell, U. S. Patent 1,509,412 (1924); R. N. Icke, C. E. Redemann, B. B. Wisegarver and G. E. Alles, *Org. Syntheses*, **29**, 72 (1949).

[4] G. Gever, THIS JOURNAL, **75**, 4585 (1953).

[5] H. Hartough, "Thiophene and Its Derivatives," Interscience Publishers, Inc., New York, N. Y., 1952, pp. 147, 225.

[6] F. W. Dunn, T. D. Waugh and K. Dittmer, THIS JOURNAL, **68**, 2118 (1946).

[7] The melting points are uncorrected.

[8] The analyses were carried out by the Clark Microanalytical Laboratory, Urbana, Ill.

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The Stereochemistry of Ether Cleavage

BY HAROLD HART AND HERBERT S. ELEUTERIO

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The steric consequences of suggested mechanisms[1] for the cleavage of ethers by acidic reagents are clear, but were not studied systematically until recently.[2] The first step in these mechanisms is the formation of an oxonium salt, or something akin to one. This may then dissociate to a carbonium ion and an alcohol (or phenol) molecule, resulting in much racemization but some inversion at the carbon undergoing C–O fission. Alternatively, the second step may be a bimolecular nucleophilic displacement of an alcohol (or phenol) molecule, again resulting in inversion. Evidence for each of these mechanisms was obtained by Burwell.[2]

We have found that a third alternative is necessary to account for the configurational changes which occur when α-phenethyl aryl ethers are cleaved by hydrogen chloride. α-Phenethyl chloride and the corresponding phenol resulted in a few minutes when hydrogen chloride was bubbled at room temperature or 50°, into these ethers, either pure or in a solvent (benzene, acetone, di-*n*-butyl ether, methanol). The configurations of some optically active α-phenethyl aryl ethers with respect to α-phenethyl chloride recently have been established.[3] When these optically active ethers were cleaved, α-phenethyl chloride was formed *with retention of configuration*, and with a minimum of 38% retention of optical purity. The same stereochemical results were obtained whether the aryl portion of the ether was phenyl, *p*-tolyl or mesityl, without a solvent, in benzene or in acetone (the extent of racemization was greater in the latter solvent).

No previously proposed mechanism for ether cleavage predicts retention of configuration at the carbon atom undergoing C–O fission. Retention has been observed, however, in the C–O fission of certain alcohols, particularly when arylalkylcarbinols react at low temperatures with hydrogen halides. Retention in the case of alcohols has been explained as an internal displacement (S_{Ni}).[4] We suggest that when an ether is cleaved by a

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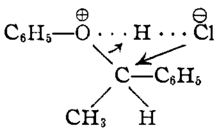
[1] See, for example, well known texts by Hammett, Remick, Alexander and others.

[2] R. L. Burwell, Jr., L. M. Elkin and L. G. Maury, THIS JOURNAL, **73**, 2428 (1951).

[3] H. Hart and H. S. Eleuterio, *ibid.*, **76**, 519 (1953).

[4] For a brief discussion and leading references, see E. R. Alexander, "Principles of Ionic Organic Reactions," John Wiley and Sons, Inc., New York, N. Y., 1950, pp. 92–94.

hydrogen halide in a non-polar solvent, the intermediate is an *oxonium ion-pair*. This may, as in the present instance, fall apart in such a way that halide ion becomes attached to the carbon atom undergoing C–O fission from the same side that the phenol molecule departs.



According to this view, the ion pair will give way to solvated ions if the solvent is made more polar. The stereochemical result may then be extensive racemization with some inversion due to shielding (S_N1); or, if the reagent is more nucleophilic and the involved carbon more susceptible to nucleophilic attack (for example, a primary carbon) the reaction course may be bimolecular nucleophilic displacement with inversion (S_N2).

These consequences are being tested by studying the influence of solvent, halide ion, kinetics and cleavage with other reagents.

Experimental

The ethers were synthesized as previously described,[3] and cleaved by passing dried (H_2SO_4) hydrogen chloride into the reaction mixture for a definite time at a given temperature. The mixture was then taken up in benzene or petroleum ether, and extracted with 20% alkali to remove the phenol produced. After drying the alkali-insoluble product over sodium sulfate and stripping the solvent, the residue was distilled *in vacuo*. All rotations are on the homogeneous material, l = 1 dm. at 25° unless otherwise indicated. The refractive index of the chloride samples was $n^{25}D$ 1.525. The yield of cleavage products was excellent in all cases, and no uncleaved ether was recovered. Cleavage of racemic α-phenethyl phenyl ether proceeded smoothly in methanol and di-*n*-butyl ether, as well as in the solvents shown in Table I. The stereochemical results obtained with optically active ethers are summarized in the table.

TABLE I

STEREOCHEMISTRY OF CLEAVAGE OF α-PHENETHYL ARYL ETHERS BY HYDROGEN CHLORIDE

Aryl group	Wt. of ether, g.	$[\alpha]^{25}D$ of ether	Time, min.	Temp., °C.	Solvent	$[\alpha]^{25}D$ of α-phenethyl chloride
Phenyl	10	− 4.1°	60	50	Benzene, 39 g.	+ 0.40°
Phenyl	10	−16.58	10	50	None	+16.75
Mesityl	5	+37.25	10	50	None	+11.15
p-Tolyl	7.5	− 2.32[a]	20	55	Acetone, 45 g.	+ 1.12

[a] $[\alpha]^{27}D$ in benzene, c 32.3.

The signs of rotation of α-phenethyl chloride and ethers of equivalent configuration are[3] (+)-chloride ≡ (−)-phenyl ether ≡ (+)-mesityl ether ≡ (−)-*p*-tolyl ether.

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Dehydration of 1,2-Diethylcyclohexanol Over Alumina

BY J. V. KARABINOS AND A. T. BALLUN

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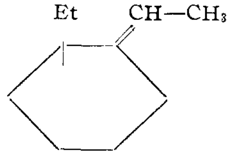
In a recent article a "1,2-diethylcyclohexene" was prepared[1] by dehydration of the corresponding cyclohexanol in the customary manner with iodine. We wish to record the dehydration of 1,2-diethylcyclohexanol over alumina catalyst in which case a single olefin was obtained which proved to be 1-ethyl-2-ethylidenecyclohexane (I) rather than one of the expected cyclohexenes, as shown by ozonolysis of the olefin to acetaldehyde and 2-ethylcyclohexanone. Since dehydrogenation of the olefin over chromia–alumina catalyst at 400–460°, conditions which usually favor the dehydrogenation of alkylcyclohexenes to alkylbenzenes, gave naphthalene in 30% yield with no evident formation of 1,2-diethylbenzene, the ethylidene structure for the olefin was substantiated further. Similar results had been reported by Ruzicka and Peyer[2] who obtained a 5 to 50% yield of naphthalene by dehydrogenation of crude "1,2-diethylcyclohexene" with selenium catalyst.

Assuming the likelihood of *trans* elimination of water[3] upon dehydration of 1,2-diethylcyclohexanol, it may be pointed out that a *cis*-1,2-diethyl structure is indicated for the cyclohexanol used in the dehydration step since a *trans*-1,2-diethylcyclohexanol should have given 1,2-diethylcyclohexene-1.



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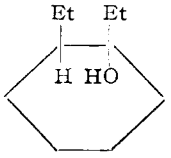

II

Experimental

1,2-Diethylcyclohexanol.—2-Chlorocyclohexanone,[4] $n^{23}D$ 1.4800, was treated with one equivalent of ethylmagnesium bromide in ether followed by benzene treatment[5] to give 2-ethylcyclohexanone[6] in an over-all yield of 35% from cyclohexanone. To a Grignard reagent prepared from 2180 g. of ethyl bromide and 480 g. of magnesium turnings was added 2520 g. of 2-ethylcyclohexanone having $n^{20}D$ 1.4557. After hydrolysis with 5% sulfuric acid, the solvent was removed from the dried ether layer and the residue was fractionated *in vacuo* on a column rated at 12 theoretical plates. After several fractionations there appeared to be no separation of isomers. Attempts to prepare derivatives from the various fractions either with phenyl isocyanate or 3,5-dinitrobenzoyl chloride resulted only in the formation of diphenylurea and 3,5-dinitrobenzoic acid, respectively. The yield of 1,2-diethylcyclohexanol amounted to 76%. A sample having $n^{20}D$ 1.4665, $d^{20}{}_4$ 0.918 and b.p. 128° (59 mm.) was used for the dehydration.

Anal. Calcd. for $C_{10}H_{20}O$: C, 76.85; H, 12.90. Found: C, 76.78; H, 12.74.

Dice, *et al.*,[1] reported $n^{25}D$ 1.4653 and $d^{25}{}_4$ 0.919 for their cyclohexanol.

Dehydration of 1,2-Diethylcyclohexanol.—By dehydration of 500 g. of 1,2-diethylcyclohexanol over alumina catalyst at 300°, followed by careful distillation on a column, rated at 80 theoretical plates, only one olefin was obtained in 90% yield, $n^{20}D$ 1.4641, $d^{20}{}_4$ 0.8411 and b.p. 175° (750 mm.).

Anal. Calcd. for $C_{10}H_{18}$: C, 86.87; H, 13.13. Found: C, 86.70; H, 13.10.

The recorded constants[1] for "1,2-diethylcyclohexene" are b.p. 170–175° (747 mm.), $n^{25}D$ 1.4598 and $d^{25}{}_4$ 0.831.

Ozonolysis of the above olefin (0.05 mole, $n^{20}D$ 1.4641) was carried out according to the directions of Henne and

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[1] J. R. Dice, L. E. Loveless, Jr., and H. L. Cates, Jr., THIS JOURNAL, **71**, 3546 (1949).

[2] L. Ruzicka and E. Peyer, *Helv. Chim. Acta*, **18**, 676 (1935).

[3] C. C. Price and J. V. Karabinos, THIS JOURNAL, **62**, 1159 (1940)

[4] M. S. Newman and M. D. Farbman, *ibid.*, **66**, 1550 (1944).

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[6] M. L. Bouveault and F. Chereau, *Compt. rend.*, **142**, 1986 (1906).