

ligroin (b.p. 60–90°) to give 12.5 g. (47% overall yield) of 1-hydroxy-4-phenyl-2-naphthoic acid (XX), m.p. 227–228° dec.

Anal. Calcd. for $C_{17}H_{12}O_3$: C, 77.26; H, 4.58. Found: C, 77.02; H, 4.47.

This compound gave a greenish-blue coloration with aqueous-alcoholic ferric chloride.

Decarboxylation of naphthol-acid XX. An 0.18 g. sample of naphthol-acid XX was heated above its melting point in a covered crucible. The resulting tarry material was recrystal-

lized from a mixture of chloroform and ligroin (b.p. 60–90°) to produce 0.10 g. (67%) of 4-phenyl-1-naphthol (XXI) as a brownish powder, m.p. 139–140° (lit. value 140°).¹⁵ This compound gave a dark blue coloration with aqueous alcoholic ferric chloride.

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(15) W. Borsch, S. Kettner, M. Giles, H. Kuhn, and R. Manteuffel, *Ann.*, 526, 21 (1936).

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, DUKE UNIVERSITY]

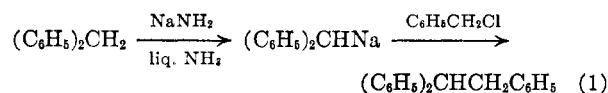
Condensations of Benzhydryl Methyl Ether Involving α -Hydrogen by Potassium Amide. Cyclization of Conjugate Addition Product by Polyphosphoric Acid¹

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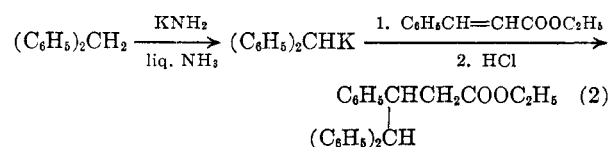
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The α -hydrogen of benzhydryl methyl ether was metalated by means of potassium amide, and the resulting potassium derivative then condensed with benzyl chloride and ethyl cinnamate. The product from the latter condensation was cyclized by means of polyphosphoric acid to form a methoxytetralone which was subsequently aromatized by means of hydrogen fluoride to give a naphthol. Some other reactions were also effected.

It is well known that one of the methylene hydrogens of diphenylmethane can be metalated readily by means of sodium amide or potassium amide in liquid ammonia, and that the resulting alkali diphenylmethide can serve as the carbanion component in several useful types of carbon-carbon condensations. One of these types of reaction involves alkylation, certain of which have been effected quantitatively (Equation 1).²



Another type of condensation involves conjugate addition such as that with ethyl cinnamate, which has been realized in good yield (Equation 2).³

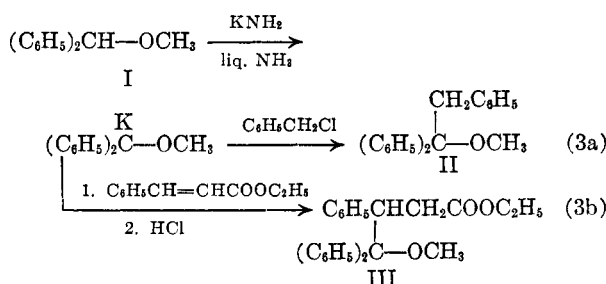


It has now been found that the α -hydrogen of benzhydryl methyl ether (I) can be metalated similarly with potassium amide, and that the resulting potassium derivative can enter into the two analogous condensations with benzyl chloride and ethyl cinnamate to form ether II and ether-ester III in yields of 63% and 62%, respectively (Equations 3a and 3b).

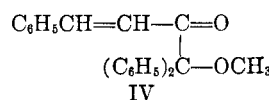
(1) Supported by the Office of Ordnance Research, U. S. Army.

(2) C. R. Hauser and P. J. Hamrick, Jr., *J. Am. Chem. Soc.*, 79, 3142 (1957).

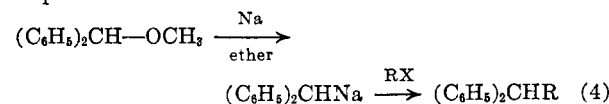
(3) M. T. Tetenbaum and C. R. Hauser, *J. Org. Chem.*, 23, 229 (1958).



The conjugate addition with ethyl cinnamate (Equation 3b) might have been accompanied by some 1,2 addition to form α,β -unsaturated ketone IV, but neither this product nor products that might have arisen from its further reaction with the potassium derivative of benzhydryl methyl ether were isolated.

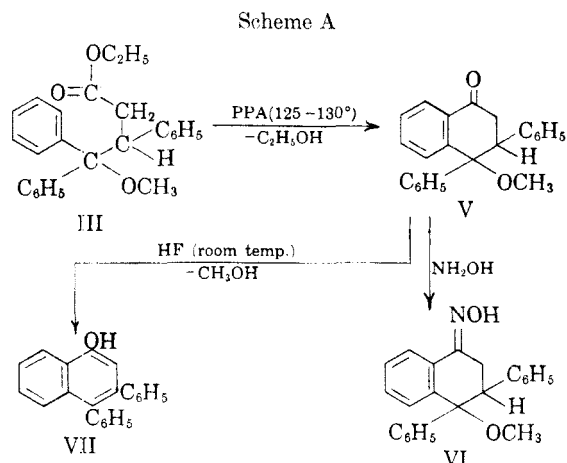


The reactions represented by equations 3a and 3b, in which the ether group remains intact, are to be distinguished from those reported by Bergmann⁴ who cleaved benzhydryl methyl ether (I) by means of metallic sodium, and then employed the resulting sodium diphenylmethide in corresponding condensations. Such a cleavage, followed by alkylation, is illustrated by equation 4, the end result of which is analogous to that represented in Equation 1.



(4) E. Bergmann, *J. Chem. Soc.*, 412 (1936); E. Bergmann and O. Blum-Bergmann, *J. Chem. Soc.*, 727 (1938).

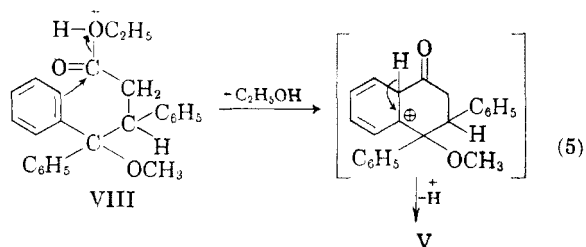
The conjugate addition of the potassium derivative of benzhydryl methyl ether with ethyl cinnamate (Equation 3b) is of particular interest, since the resulting ester was cyclized by means of polyphosphoric acid (PPA) to form ether-ketone V in 90% yield. This cyclic product (V) was not only converted to the corresponding oxime (VI) but it was also aromatized by means of hydrogen fluoride to form a known naphthol (VII). These reactions are summarized in Scheme A.



That the cyclization product from ether-ester III was ether-ketone V was established not only by the reactions shown in Scheme A but also by its infrared absorption spectrum which gave a strong band for the carbonyl group and none for an hydroxyl group. On the other hand, the infrared absorption spectrum of the product subsequently obtained on treatment with hydrogen fluoride showed a strong band for the hydroxyl group and none for a carbonyl group, in agreement with structure VII.

Since ether-ketone V was readily isolated as a sharp melting product, it appeared to consist largely of only one of the two possible diastereoisomers.

The mechanism for the cyclization of ether-ester III may be considered to involve the protonated intermediate VIII (Equation 5).



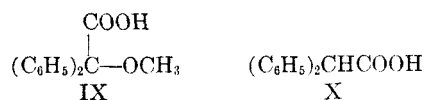
It seems rather remarkable that this cyclization of the protonated ether-ester VIII, involving the loss of ethanol, was not accompanied by the elimination of methanol (from the β,γ -position) to form naphthol VII since the methoxy group in both the starting ether-ester III and the product

ether-ketone V was presumably also protonated by the excess of polyphosphoric acid employed.

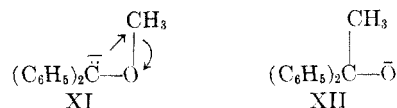
It should be mentioned that concentrated sulfuric acid at room temperature converted ether-ketone V to water soluble material which was presumably a sulfonated product. Boiling concentrated hydrochloric acid and potassium amide (two equivalents) in refluxing ether failed to affect ether-ketone V which was largely recovered. The latter reagent has been shown to effect the trans β -elimination of methanol from certain ethers having β -hydrogen activated by one or two phenyl groups.⁵ Ether-ketone V was also recovered after being heated above its melting point.

It is noteworthy that, whereas strong acids failed to effect the aromatization of ether-ketone V to form naphthol VII, hydrogen fluoride brought about this reaction even at room temperature. Incidentally, an attempt to effect the overall cyclization and aromatization of ether-ester III to form naphthol VII by means of hydrogen fluoride produced only an alkali insoluble tar.

Other reactions of benzhydryl methyl ether. Besides the condensations in liquid ammonia described above, benzhydryl methyl ether (I) was carbonated through its potassium derivative, after replacing the ammonia by ether, to form ether-acid IX but the yield was low (10%). The corresponding carbonation of potassium diphenylmethide in ether to form acid X has been realized in 90% yield.⁶



It is possible that the reaction in ethyl ether was accompanied by the Wittig type of rearrangement (indicated in XI) to form the anion of diphenylmethylcarbinol (XII), but none of this carbinol was isolated



Certain benzyl ethers, for example, dibenzyl ether, have been observed to undergo such 1,2 shifts with potassium amide in ethyl ether.⁷

EXPERIMENTAL⁸

Benzhydryl methyl ether. This ether was prepared by a modification of the method of Bergmann.⁹ A solution of 100 g. of

(5) P. J. Hamrick, Jr., S. W. Kantor, and C. R. Hauser, unpublished result.

(6) R. S. Yost and C. R. Hauser, *J. Am. Chem. Soc.*, **69**, 2325 (1947).

(7) C. R. Hauser and S. W. Kantor, *J. Am. Chem. Soc.*, **73**, 1437 (1951).

(8) Melting points are uncorrected. Analyses are by Galbraith Microanalytical Laboratories, Knoxville, Tenn.

(9) E. Bergmann and J. Hervey, *Ber.*, **62**, 915 (1929).

benzhydryl bromide in 333 ml. of commercial absolute methanol was stirred overnight and an aqueous solution of potassium hydroxide was then added. The heavy organic layer was separated, and combined with several ethyl ether extracts of the aqueous layer. After drying over Drierite, the solvent was removed under reduced pressure on the steam bath, and the residual brown oil distilled *in vacuo* to give 77 g. (97%) of the colorless ether I, b.p. 129° at 5 mm. (reported b.p. 125° at 5 mm.;¹⁰ 147–148° at 17 mm.).⁹

Alkylation of ether I to form ether II. To a stirred suspension of 0.1 mole of potassium amide¹¹ in 500 ml. of liquid ammonia was carefully added 19.8 g. (0.1 mole) of benzhydryl methyl ether in an equal volume of anhydrous ethyl ether. The resulting dark orange suspension of the potassium derivative was stirred for 15 min., and 12.7 g. (0.1 mole) of benzyl chloride in an equal volume of anhydrous ethyl ether then added. The color was discharged, and a white precipitate was formed. After stirring one hour, the liquid ammonia was evaporated on the steam bath as an equal volume of anhydrous ethyl ether was added. The resulting white suspension was refluxed 15 min., cooled, and decomposed with iced hydrochloric acid. The yellow ether layer was separated, and combined with several ether extracts of the aqueous layer. After drying over Drierite, the ethyl ether was evaporated under reduced pressure on the steam bath. The residual red-brown oil was worked up to give, after recrystallization from a mixture of methanol and benzene, 18 g. (63%) of white crystals of methyl 1,1,2-triphenylethyl ether (II), m.p. 90–91°. A second recrystallization raised the melting point to 93° in agreement with the literature value.¹²

Conjugate addition with ethyl cinnamate to form ether-ester. To the stirred dark orange suspension of the potassium derivative of benzhydryl methyl ether prepared from 0.1 mole each of potassium amide and ether I in 500 ml. of liquid ammonia and 50 ml. of ethyl ether, was added 17.6 g. (0.1 mole) of ethyl cinnamate in an equal volume of anhydrous ethyl ether. The color was mostly discharged. The liquid ammonia was replaced by anhydrous ethyl ether and the resulting suspension was refluxed on the steam bath for 30 min. The mixture was hydrolyzed with iced hydrochloric acid, and the yellow ether layer, after being combined with several ether extracts of the aqueous layer, was dried over Drierite. The solvent was removed to leave 23 g. (62%) of ethyl 3,4,4-triphenyl-4-methoxybutyrate (III) as a white crystalline compound, m.p. 130–133°. Three recrystallizations from ethyl ether raised the melting point to 139–140°.

Anal. Calcd. for $C_{25}H_{26}O_2$: C, 80.18; H, 7.00. Found: C, 79.99; H, 7.07.

Cyclization of ether-ester III to form cyclic ketone V. A mixture of 7 g. of ethyl 3,4,4-triphenyl-4-methoxybutyrate (III) and excess of polyphosphoric acid¹³ was stirred and heated at 125–130° for 30 min. The resulting brown solution was cooled, ice water added, and the mixture extracted with ethyl ether. The yellow ethereal solution was dried over Drierite, and the solvent removed under reduced pressure. There was obtained 6 g. (98%) of pale yellow 3,4-diphenyl-4-methoxy-1-tetralone (V) m.p. 104–106°. Three recrystallizations from ethanol gave white crystals, m.p. 106.5–107.5°.

Anal. Calcd. for $C_{23}H_{20}O_2$: C, 84.12; H, 6.14. Found: C, 84.17; H, 6.33.

(10) P. S. Skell, Thesis, Duke University, 1942, p. 54.

(11) R. S. Yost and C. R. Hauser, *J. Am. Chem. Soc.*, **69**, 2325 (1947).

(12) K. Ziegler and B. Schnell, *Ann.*, **437**, 248 (1924).

(13) We are indebted to the Victor Chemical Works, Chicago, Ill., for a generous sample of polyphosphoric acid.

An infrared absorption spectrum of this ether-ketone V gave a strong carbonyl band at 5.76 μ . A sample of this compound was converted to the corresponding oxime following the general directions of Shriner and Fuson.¹⁴ After recrystallization from ethanol-water, the oxime (VI) was obtained as a white powder that softened at 140° and melted at 178°.

Anal. Calcd. for $C_{23}H_{21}O_2N$: C, 80.44; H, 6.16. Found: C, 80.69; H, 5.93.

Aromatization of ether-ketone V to form naphthol VII. To 138 g. of anhydrous liquid hydrogen fluoride contained in a polyethylene bottle was added one gram of 3,4-diphenyl-4-methoxy-1-tetralone (V) and the resulting dark solution allowed to evaporate in the hood at room temperature overnight. The dark residue was extracted with ether, and the ethereal solution was dried over Drierite. The solvent was removed, and the residual solid was taken up in potassium hydroxide solution. Iced-hydrochloric acid was added to precipitate 0.9 g. (98%) of yellowish pink 3,4-diphenyl-1-naphthol (VII) m.p. 143–144°, in agreement with the reported melting point.¹⁵ This compound was almost white after being washed with petroleum ether (b.p. 30–60°). A recrystallization from ligroin (b.p. 60–90°) did not change the melting point. An infrared absorption spectrum gave a strong hydroxyl band at 2.77 μ .

This naphthol (0.9 g.) was boiled for one minute with 6 ml. of acetic anhydride and three drops of concentrated sulfuric acid essentially as described by Smith and Hoehn.¹⁵ The solution was poured onto ice and the product was recrystallized twice from ethanol to give 0.8 g. (78%) of an almost colorless powder of the acetyl derivative of VII, m.p. 165–166°, (reported m.p. 162.5–163°).¹⁵

Carbonation to form ether-acid IX. The potassium derivative of benzhydryl methyl ether (0.1 mole) was prepared in liquid ammonia as above, and stirred for 15 min. The liquid ammonia was then replaced by anhydrous ethyl ether, and the resulting suspension refluxed for 30 min. The mixture was cooled, and excess crushed Dry Ice carefully added with stirring. When the excess Dry Ice had evaporated, water and ethyl ether were added, and the brown layers separated. The aqueous alkaline layer was combined with an alkali extract of the ether layer, and, after filtration to remove tarry material, the cooled solution was acidified with iced-hydrochloric acid. The resulting precipitate was collected on a funnel to give 7 g. of crude, tan carboxylic acid. A solution of this product in aqueous potassium hydroxide was boiled with Norit. Acidification with hydrochloric acid precipitated a white solid from which 0.3 g. of benzoic acid was removed by washing with hot water. The methyl ether of benzoic acid (IX) was obtained in about 10% yield melting at 108.5–109.5 (reported m.p. 111–112°;¹⁶ 100°).¹⁷

Evaporation of the original ether layer produced a dark brown oil that partially solidified. The mixture was filtered. The solid (1.5 g.) melted at 138–140°, and at 142–143° after two recrystallizations from ethyl ether. The filtrate obtained on removing the 1.5 g. of solid was distilled to give 5 g. (25%) of recovered ether I.

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(14) R. L. Shriner and R. C. Fuson, *The Systematic Identification of Organic Compounds*, John Wiley and Sons, Inc., New York, N. Y., 1948, p. 202 (B).

(15) L. I. Smith and H. H. Hoehn, *J. Am. Chem. Soc.*, **61**, 2619 (1939).

(16) See Heilbron, *Dictionary of Organic Compounds*, Oxford University Press, New York, 1953, Vol. I, p. 252.

(17) S. A. Setlur, A. N. Kothare, and V. V. Nadkarny, *J. Univ. Bombay*, **12A**, Pt. 3, 68–70 (1943).