dithiocyanoanthracene, m. p. 198–201°; yield 250 mg. (45%). After five crystallizations from benzene–methanol the substance melted at 206.7–207.8° (ferric chloride test negative). Oxidation yielded anthraquinone, m. p. 284.1–284.7° (mixed melting point). The disubstitution product was also isolated in an experiment utilizing only one equivalent of reagent.

Anal. Calcd. for $C_{16}H_8S_2N_2$: C, 65.72; H, 2.76. Found: C, 65.52; H, 2.79.

The mother liquors of the above preparation afforded 350 mg. of fine yellow needles of a mixture which resisted attempted fractionation from benzene–methanol, acetic acid, or methanol, and which melted consistently at about 125–145°. When a benzene solution of 150 mg. of the mixture was allowed to stand in contact with alumina, hydrogen cyanide was evolved and elution of the material adsorbed on the alumina afforded a small amount of a substance which when crystallized repeatedly melted at 211–212° (6 mg.). This probably is impure 9,9′-dianthryl disulfide (m. p. 223°)[38] arising from the 9-thiocyano derivative, for a small comparison sample prepared by the method of Cook, Heilbron and Walker[38] melted at the same temperature and gave no depression on admixture.

Trials with 1,2,5,6-Dibenzanthracene.—In typical experiments suspensions of 500-mg. portions of the hydrocarbon in either benzene or carbon tetrachloride containing 4.4 equivalents of thiocyanogen were shaken for three to four days, but the hydrocarbon was largely recovered unchanged (48–82% recovery) and no thiocyano derivative could be isolated. In another trial a solution of 150 mg. of dibenzanthracene in 100 cc. of acetic acid was cooled to 15° and treated with 0.5 g. of sodium thiocyanate in 10 cc. of acetic acid, followed by 0.16 cc. of bromine in 3 cc. of acetic acid, added by drops. After standing overnight, the material precipitated by water was processed by crystallization and chromatographic adsorption, but it afforded only starting material (130 mg., m. p. 264–265°). In trials with black copper thiocyanate[7] there was no sign of a reaction.

Summary

The ready reaction of at least some of the more potently active carcinogens with thiocyanogen provides an interesting chemical analogy lending plausibility to the hypothesis that an administered carcinogen can combine with a proteinoid constituent of the cell by virtue of the opening of a disulfide linkage and fixation of the hydrocarbon to one of the sulfur atoms.

CONVERSE MEMORIAL LABORATORY
CAMBRIDGE, MASSACHUSETTS
RECEIVED MAY 27, 1941

---

[38] Cook, Heilbron and Walker, *J. Chem. Soc.*, **127**, 2254 (1924).

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, THE UNIVERSITY OF TEXAS]

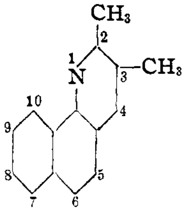
The Nitrogen Compounds in Petroleum Distillates. XXIII. Isolation of 2,3-Dimethylbenzo[h]quinoline (I) and 2,4-Dimethylbenzo[h]quinoline (II) from California Petroleum

BY LESLIE M. SCHENCK AND J. R. BAILEY

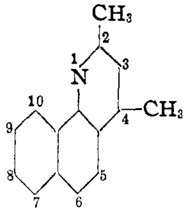
Introduction

Cumulative extraction[1] of gas oil bases in the 355–365° range from California petroleum[2] effects relatively sharp segregation of the component base hydrochlorides in the ratio 1:4 between the aqueous and solvent phases, respectively. The high refractivity of the basic admixture from the aqueous hydrochloride layer suggested possible trinuclear structure. Processing of this material yielded 2,3-dimethylbenzo[h]quinoline (I) and 2,4-dimethylbenzo[h]quinoline (II), neither of which have been reported previously from a natural source.

From selenium dioxide oxidation of (II) was obtained a $C_{13}H_7N(COOH)_2$ dicarboxylic acid; this behavior is suggestive of a structure in which methyl groups are in the positions alpha and gamma to nitrogen. Lack of material prevented decarboxylation of this acid to the parent compound. Eliminating an acridine homolog on the basis of active methyl groups, the $C_{15}H_{13}N$ base (II) was one of the three isomeric 2,4-dimethylbenzoquinolines. Synthesis of 2,4-dimethylbenzo[h]quinoline[3] from α-naphthylamine and acetylacetone yielded a product identical with II.



I



II

Selenium dioxide oxidation of (I) yielded a

---

[1] Perrin and Bailey, THIS JOURNAL, **55**, 4136 (1933).

[2] This material was supplied by the Union Oil Company of California.

[3] Synthesis of this base from the same intermediates has been reported previously by Combes, *Compt. rend.*, **106**, 1537 (1888); and with acetaldehyde and acetone as the carbonyl reagents by Reed, *J. prakt. Chem.*, [2] **35**, 312 (1887). In both cases the melting point of the base from petroleum ether is reported as 44° (uncor.). In this work, both the natural and synthetic products were found to melt at 55–56° (cor.) from the same solvent.

$C_{14}H_{10}NCOOH$ monocarboxylic acid, indicative of one active methyl. In correlation with quinoline homologs previously encountered in the Texas laboratory from petroleum, the non-reactive methyl of the $C_{15}H_{13}N$ isomer was assumed to be in position 3. Synthesis of the 2,3-dimethylbenzoquinoline isomer of II from tiglic aldehyde and α-napthylamine[4] gave a compound identical with (I).

Experimental

Isolation of 2,3-Dimethylbenzo[h]quinoline (I).—Bases (1.5 liter) boiling at 365° and having $n^{20}D$ 1.5854 were subjected to cumulative extraction[1] by agitating one hour with 6 *N* hydrochloric acid (1 vol.) and chloroform (1.2 vol.). Through multiple acid extraction,[5] the bases (300 ml.) concentrated in the aqueous phase were resolved into four equal fractions. The first fraction, representing the admixture of weaker bases, was rectified with some decomposition into six volume fractions with a boiling range of 175–178° (3 mm.) and $n^{25}D$ values ranging from 1.6241 to 1.6341.

The first distillation fraction was precipitated as a flocculent hygroscopic yellow salt through addition of concentrated nitric acid (2.5 ml.) to the bases (12 ml.) in acetone (70 ml.). Since no suitable solvent was found for recrystallizing the nitrate, direct conversion of this salt to the picrate was made in alcoholic solution. This latter derivative crystallizes to purity from 70% acetic acid as yellow platelets melting at 228–229° (cor.). Similar treatment of the remaining distillation fractions yielded only a small additional quantity of the picrate.

The base, liberated from the picrate by ammonium hydroxide, crystallized as needles melting at 83–84° (cor.). from either methanol or ligroin.

Anal. Calcd. for $C_{15}H_{13}N$: C, 86.91; H, 6.28; N, 6.76. Found: C, 86.78; H, 6.39; N, 6.81.

Acid Sulfate.—Upon addition of concd. sulfuric acid to an acetone solution of the base, this salt precipitates as a pink flocculent mass. Following recrystallization from ethanol, the melting point of 265–267° (cor.) without decomposition was observed.

Anal. Calcd. for $C_{15}H_{13}N \cdot H_2SO_4$: SO_4, 31.46. Found: SO_4, 31.27.

3-Methylbenzo[h]quinoline-2-carboxylic Acid.—The base (I) (0.372 g.) was refluxed with selenium dioxide (0.216 g.) in absolute ethanol (10 ml.) for twelve hours, a resinous gum giving an aldehyde test being obtained on evaporation of the solvent. Without purification, the aldehyde was redissolved in acetone (15 ml.) and oxidized by refluxing one hour with 30% hydrogen peroxide (1.5 ml.). A portion of the acid, obtained in 20% yield, was converted to the silver salt in ammoniacal solution through addition of silver nitrate and acidification with dilute nitric acid. The acid crystallizes from dilute ethanol, and melts undecomposed at 162–163° (cor.).

Anal. Calcd. for $C_{15}H_{16}NO_2Ag$: Ag, 31.4. Found: Ag, 31.3. Calcd. for $C_{15}H_{11}NO_2$: N, 5.91. Found: N, 6.20.

Synthesis of 2,3-Dimethylbenzo[h]quinoline.—In accordance with Rhode's synthesis of 2,3-dimethylquinoline,[4] equimolar portions of tiglic aldehyde and α-naphthylamine were heated for four hours on the steam-bath with a large excess of concd. hydrochloric acid. After separation from resinous admixtures, the acid solution was neutralized with caustic and ether extracted. The product, obtained in small yield, was purified as its picrate from ethanol. The melting point of a mixture of this base and the petroleum base showed no depression; likewise their mixture of picrates showed no depression in melting point.[6]

Isolation of 2,4-Dimethylbenzo[h]quinoline (II).—The processing of bases (1.4 l.) with b. p. 355° and $n^{20}D$ 1.5764 by cumulative extraction[1] concentrated 18% of the material in the aqueous layer. Following liberation of the aqueous hydrochlorides, these bases were resolved into three fractions, employing counter current acid extraction. Fractionation attempts were abandoned due to loss through thermal decomposition. Upon salification of the first acid extraction fraction in acetone–ether solution with concd. sulfuric acid, an oily sulfate of the base precipitated, and was crystallized in the form of fine needles to a constant melting point of 227–228° (cor.) from the solvent pair methanol–acetone.

Anal. Calcd. for $C_{15}H_{13}N \cdot H_2SO_4$: SO_4, 31.46. Found: SO_4, 31.29.

Base.—Liberated from the acid sulfate by addition of ammonium hydroxide, this colorless solid crystallizes from dilute ethanol as irregular needles melting at 55–56° (cor.).

Anal. Calcd. for $C_{15}H_{13}N$: C, 86.91; H, 6.39; N, 6.76. Found: C, 86.80; H, 6.31; N, 6.87.

Picrate.—Prepared in alcoholic solution, the picrate crystallizes from 50% acetic acid as lemon colored needles melting undecomposed at 230–231° (cor.).

Anal. Calcd. for $C_{21}H_{16}N_4O_7$: C, 57.78; H, 3.70. Found: C, 57.53; H, 3.73.

Nitrate.—Upon addition of the calculated amount of concd. nitric acid to the base in acetone, the precipitated nitrate crystallizes as straw colored needles from ethyl alcohol, melting with decomposition at 173° (cor.).

Anal. Calcd. for $C_{15}H_{13}N \cdot HNO_3$: NO_3, 23.12. Found: NO_3, 23.31.

Benzo[h]quinoline-2,4-dicarboxylic Acid.—To 0.3 g. of base (II) in ethanol (10 ml.) was added selenium dioxide (0.5 g.) in small portions and then processed as previously described in the oxidation of 2,3-dimethylbenzo[h]quinoline. The yield of acid was extremely small, 0.2 g. of base being recovered.

Anal. Calcd. for $C_{15}H_7NO_4Ag_2$: Ag, 44.1. Found: Ag, 43.6.

Synthesis of 2,4-Dimethylbenzo[h]quinoline.—Equimolar quantities of acetylacetone and α-naphthylamine were condensed in accordance with Combes.[3] The benzoquinoline was obtained in 80% yield, and purified

---

[4] *Cf.* Rhode, *Ber.*, **20**, 1911 (1887).

[5] Morton, "Laboratory Technique in Organic Chemistry," McGraw-Hill Book Company, Inc., New York, N. Y., 1938, p. 198.

[6] Axe and Bailey [THIS JOURNAL, **60**, 3032 (1938)] reported isolation of a $C_{15}H_{13}N$ base of probable trinuclear structure. A sample of their product proved identical with our authentic 2,3-dimethylbenzo[h]quinoline.

by crystallization from petroleum ether and methanol. The melting point of a mixture of this base and the petroleum product showed no depression.

Summary

Two benzo[h]quinoline homologs have been isolated from California petroleum. Their structures, formulated as 2,3-dimethylbenzo[h]quinoline and 2,4-dimethylbenzo[h]quinoline, respectively, have been confirmed by synthesis.

AUSTIN, TEXAS RECEIVED MAY 26, 1941

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF HARVARD UNIVERSITY]

Synthesis of 2-Hydroxy-3,4-benzpyrene and 2-Methyl-3,4-benzpyrene

BY LOUIS F. FIESER AND HANS HEYMANN

References to syntheses of the 2′-, 3′-, 4′-, 5-, and 6-monomethyl derivatives of 3,4-benzpyrene have been summarized in a paper[1] reporting the synthesis of a sixth isomer (9-methyl). In the series of monohydroxy compounds, the 4′-,[2] 5-[3] and 6-[4]isomers have been synthesized for biological testing. Apart from the preparation of 5-derivatives by direct substitution of the hydrocarbon, these substances have been produced by syntheses in which the 3,4-benzpyrene ring system is elaborated starting with pyrene (3′- and 4′-CH_3, 4′-OH), perinaphthane or a homolog (2′-, 3′-, 5-, 6- and 9-CH_3), or a chrysenoid intermediate (6-OH). The present paper reports syntheses of 2-derivatives from 1′-keto-1′,2′,3′,4′-tetrahydro-1,2-benzanthracene (V) as the essential intermediate. The fifth ring was built on by orthodox reactions, but the intermediate was prepared by a novel method which offers opportunities for additional synthetic applications.

1′ - Keto - 1′,2′,3′,4′ - tetrahydro - 1,2 - benzanthracene was prepared by Cook and Robinson[5] by the cyclization of γ-2-anthrylbutyric acid (IV), which they obtained from anthracene in 9% overall yield by succinoylation and reduction, as reported from this Laboratory.[6] As an alternate route, we investigated the application of the phthalic anhydride synthesis to γ-phenylbutyric acid. Although the ethyl ester of this substance failed to enter into the Friedel and Crafts reaction in nitrobenzene, tetrachloroethane or carbon bisulfide solution, it was found that the acid itself can be condensed satisfactorily with phthalic anhydride in tetrachloroethane in the presence of three equivalents of aluminum chloride. As in a recorded instance,[7] the use of slightly deteriorated aluminum chloride facilitated the purification of the product. The keto acid I was separated easily as a complex and isolated pure in 58% yield.

For the reduction of the carbonyl group of I, the method of hydrogenation over copper chromite without solvent, which has been applied with success to monobasic keto acids,[8] gave even moderate yields only when conducted on a small scale, and it was subject to the difficulty that the keto diacid destructively attacked the catalyst and gave chromium-contaminated material. Reduction with zinc dust and alkali gave only resinous material. It was found that the reduction can be accomplished very smoothly by hydrogenation over copper chromite in a weakly alkaline aqueous medium.[9]

Cyclization of the diphenylmethane diacid II was accomplished more satisfactorily with hydrogen fluoride than with sulfuric acid and gave a product characterized as the anthrone acid III by reduction to the known anthrylbutyric acid IV. That the diacid yields an anthrone rather than a tetralone derivative is in line with observations on the relative ease of formation of these ring systems in non-competitive instances (zinc chlo-

---

[1] Fieser and Novello, THIS JOURNAL, **62**, 1855 (1940).

[2] Fieser, Hershberg and Newman, *ibid.*, **57**, 1509 (1935).

[3] Fieser and Hershberg, *ibid.*, **60**, 2542 (1938); **61**, 1565 (1939).

[4] Fieser and Johnson, *ibid.*, **62**, 575 (1940).

[5] Cook and A. M. Robinson, *J. Chem. Soc.*, 505 (1938).

[6] Fieser and Peters, THIS JOURNAL, **54**, 4355 (1932). The procedures were not described in detail in this paper and the yield reported for the succinoylation was miscalculated. We used over twice the proportion of aluminum chloride employed by Cook and Robinson (150 g. for 89 g. of anthracene) and obtained yields of 21 and 22% (C. and R., 13%). Like Cook, Robinson and Roe, *J. Chem. Soc.*, 266 (1939), we investigated the succinoylation of 9,10-dihydroanthracene; in this case the use of 2.2 times the amount of aluminum chloride employed by the English investigators apparently altered the course of the reaction, for the sole acidic product encountered was β-2-anthroylpropionic acid (11% yield).

[7] Scholl, Dehnert and Wanka, *Ann.*, **493**, 57 (1932).

[8] Fieser and Hershberg, THIS JOURNAL, **59**, 1028 (1937).

[9] Subsequent to this observation, the method was applied successfully in other instances already reported: Fieser and Cason, *ibid.*, **62**, 1293 (1940); Fieser and Clapp, *ibid.*, **63**, 319 (1941); Fieser and Daudt, *ibid.*, **63**, 782 (1941). The hydrogenation of aliphatic keto acids to hydroxy acids in alkaline solution is described by Allen, Wyatt and Henze, *ibid.*, **61**, 843 (1939).