this pharmacology will be presented soon in an appropriate journal.

The experimental details given below serve to exemplify the general methods employed throughout the reaction scheme.

EXPERIMENTAL[8]

2-Methyl-4-hydroxy-5-(β,β-diethoxy)ethylpyrimidine. Acetamidine hydrochloride (0.05 mole; 4.7 g.) was added to a 75-ml. solution of 0.1 mole sodium ethoxide. After 0.5 hr. of stirring at room temperature, the resultant sodium chloride was removed by filtration. The filtrate was added to ethyl α-cyano-γ,γ-diethoxybutyrate (0.05 mole; 11.5 g.) and the reaction solution was refluxed for 5 hr. Three fourths of the solvent was driven off in a dish over steam and the remaining slurry was dissolved in 80 ml. of ice water. The desired pyrimidine was precipitated at *p*H 7.0 in a pure state by the addition of acetic acid. After chilling overnight, filtering, and vacuum desiccating (Drierite), 10.8 g. of the white product was obtained representing an 89% yield. The pyrimidine decomposed at 253–260° to a dark oil.

2-Methyl-4-hydroxypyrrolo[2,3-d]pyrimidine. The above pyrimidine (4.5 g.; 0.187 mole) was added to a solution of 2 ml. of concd. sulfuric acid in 110 ml. of 95% ethanol and refluxed for 2 hr. Upon addition of an equal volume of water and by chilling overnight, 2.1 g. of the white amorphous product was obtained. The pyrrolopyrimidine neither melted nor decomposed (below 300°) and was sufficiently pure for analysis.

2-Methyl-4-chloropyrrolo[2,3-d]pyrimidine. A suspension of 25 g. (0.168 mole) of the above hydroxypyrrolopyrimidine in 175 ml. of phosphorus oxychloride was refluxed for 45 min. after solution was attained. The excess phosphorus oxychloride was removed under reduced pressure using a 55–60° water bath. The residual viscous oil was dropped slowly into 1 l. of ice water mixture with vigorous stirring. The resultant chloro compound was extracted from the suspension using three 275-ml. portions of ether. The combined ethereal extracts were dried over anhydrous sodium sulfate. When taken to dryness, 23.2 g. (83% yield) of slightly yellow product remained which was sufficiently pure to be used as an intermediate.

2,7-Dimethyl-4-chloropyrrolo[2,3-d]pyrimidine. Five grams (0.03 mole) of 2-methyl-4-chloropyrrolopyrimidine was added to 1.9 g. of sodium methoxide (0.035 mole) in 50 ml. of absolute ethanol at 5–10°. To this was added 0.0388 mole (2.4 ml.) of methyl iodide and the reaction was allowed to proceed in a sealed flask for 2 days with occasional shaking, in a 40–45° bath. The solvent was allowed to evaporate in a dish at room temperature. The remaining solid was triturated with 30 ml. of cold water, filtered off and vacuum-desiccated, yielding 4.0 g. (70% yield) of the desired product. This chloro compound may be used in this state as an intermediate (crude m.p. 119–120°).

Reactions of amines with 4-chloropyrrolopyrimidines. Method A. 2-Phenyl-4-benzylaminopyrrolo[2,3-d]pyrimidine. One gram of 2-phenyl-4-chloropyrrolo[2,3-*d*]pyrimidine (0.0043 mole) was added to 35 ml. of water containing 0.9 g. (0.0065 mole) of potassium carbonate and 1.0 g. (0.0093 mole) of benzylamine. The mixture was refluxed rapidly for 3 hr. After cooling overnight, 1.2 g. of the crude 2-phenyl-4-benzylamino derivative was obtained (92% yield). The product recrystallized from benzene-heptane melted at 162–164°.

Method B. 2-Methyl-4-(2'-methoxy)anilinopyrrolo[2,3-d]pyrimidine. Into 17 ml. of dimethylformamide was added 2.06 g. (0.123 mole) of 2-methyl-4-chloropyrrolopyrimidine and 6.04 g. (0.049 mole) of *o*-anisidine. The reaction mixture was refluxed for 1.5 hr. An equal volume of water was added and the mixture was chilled overnight. After filtration and vacuum dessication, 3.1 g. (99% yield) of tan product was obtained. Upon recrystallization from benzene-heptane, the colorless product melted at 255–256° with evidence of decomposition.

Anal. Calcd. for $C_{14}H_{14}N_4O$: C, 66.1; H, 5.5. Found: C, 66.3; H, 5.7.

Reaction with ammonia. 2-Methyl-4-aminopyrrolo[2,3-d]pyrimidine. Two grams (0.0123 mole) of 2-methyl-4-chloropyrrolopyrimidine was suspended in 40 ml. of concd. aqueous ammonia and heated in a bomb at 145° for 4.5 hr. After driving off the excess ammonia on the steam bath the pure 4-amino compound was filtered off yielding 1.3 g. of product which decomposed at 305–307°.

Anal. Calcd. for $C_7H_8N_4$: N, 37.8. Found: N, 37.6.

Acknowledgment. We wish to thank Dr. Samuel Blackman and Mr. Charles Marr for their microanalytical contribution.

TUCKAHOE, N. Y.

(8) All melting points uncorrected on a Köfler hot plate.

[CONTRIBUTION FROM AVERY LABORATORY, UNIVERSITY OF NEBRASKA]

Indenoquinolines. I. Derivatives of 11*H*-Indeno[1,2-*b*]quinoline

NORMAN H. CROMWELL AND RONALD A. MITSCH[1]

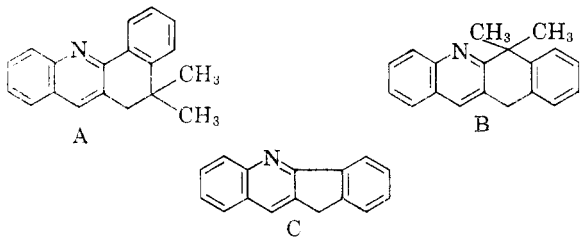
Received March 1, 1961

11*H*-Indeno[1,2-*b*]quinolin-11-one (III) adds organometallic reagents in a 1,2-fashion to produce tertiary carbinols. Hydrogenation of III by the Meerwein-Ponndorf method produced only the secondary alcohol while catalytic hydrogenation gave some hydrogen addition to the heterocyclic ring. 11*H*-Indeno[1,2-*b*]quinoline (II) reacted with *N*-bromosuccinimide to produce the 11-bromo derivative which was in turn converted to 11-substituted amino derivatives. The *N*-oxide of II was prepared, which was converted with phosphorus oxychloride to the 10-chloro derivative. These compounds have been synthesized for biological study by others.

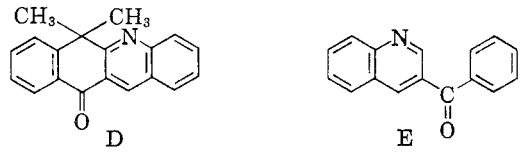
As a logical extension of current investigations of some new chemistry of polycyclic nitrogen heterocyclic compounds, we have now extended our studies to include derivatives of the 11*H*-indeno-[1,2-*b*]quinolines (C) which are related structurally to the benz[*c*]acridines (A)[2] and benz[*b*]acridines

(1) U. S. Public Health fellow, 1958–1960, National Institute of Allergy and Infectious Diseases.

(2)(a) V. L. Bell and N. H. Cromwell, *J. Org. Chem.*, 23, 789 (1958); (b) N. H. Cromwell and V. L. Bell, *J. Org. Chem.*, 24, 1077 (1959).



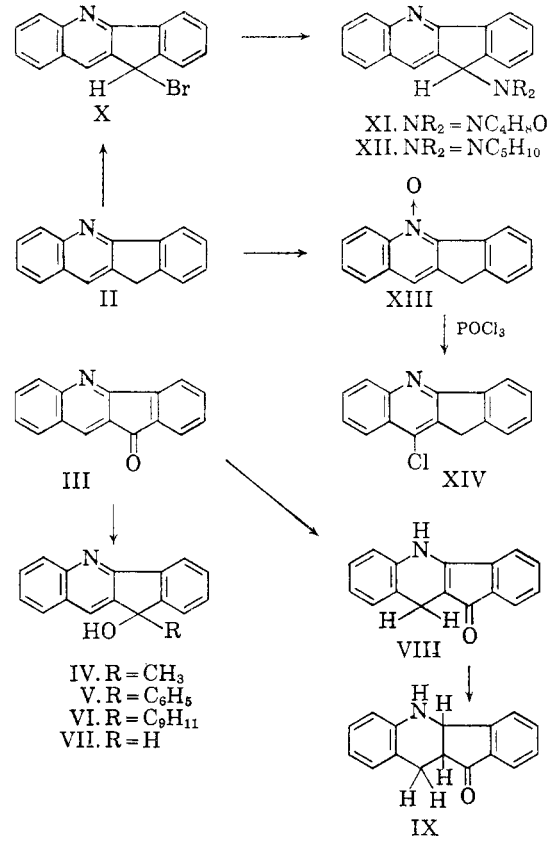
(B)[3] previously investigated. It seemed of interest to make available for general biological testing and as carcinogenic and antitumor agents certain of the indenoquinoline derivatives which would have structures analogous to some of the benzacridines previously synthesized in this laboratory.[2,3] Of special interest was a study of the reactions of the known ketone, 11*H*-indeno[1,2-*b*]quinolin-11-one (III) with organometallic and hydrogenation reagents as had been done previously[3] with the analogous 6,6-dimethyl-11-keto-6,11-dihydrobenz-[*b*]acridine (D). This latter ketone was reported to add methylmagnesium bromide[3a] in the normal 1,2-manner to give a tertiary carbinol, but to react with phenylmagnesium bromide and catalytic hydrogen to produce keto dihydrobenz[*b*]acridans[3b] in which the addenda turn up on the nitrogen heterocyclic ring.



Previously Fuson and Miller[4] had described the conjugate addition of phenylmagnesium bromide to 3-benzoylquinoline (E) which may be looked upon as an open model of our ketones (III and D). They offered spectral evidence to show the structure of the high-melting, yellow colored crystalline addition product to be 3-benzoyl-4-phenyl-1,4-dihydroquinoline.

The 11*H*-indeno[1,2-*b*]quinolin-11-one (III) for the work reported here was prepared either by the decarboxylation of 10-carboxy-11*H*-indeno[1,2-*b*]quinolin-11-one[5] or from the condensation of *o*-aminobenzaldehyde with 1,3-indandione using either basic or acid conditions.

Ketone III gave an 85% yield of the tertiary carbinol IV on reaction with methylmagnesium bromide. The ultraviolet spectrum of IV was very similar to that of the parent 11*H*-indeno[1,2-*b*]quinoline (II). The absence of a carbonyl stretching band and absorption in the hydroxyl stretching region of the infrared spectrum at 3580 cm.$^{-1}$ by a chloroform solution of the tertiary carbinol IV confirmed its structure. Heating IV with chloranil under the conditions previously used to aromatize the keto acridans[3b] produced no change.



Both phenylmagnesium bromide and phenyllithium reacted with the ketone III to produce the same colorless addition product. The chloroform solution of the addition product V showed a free hydroxyl infrared band at 3600 cm.$^{-1}$ and no carbonyl absorption in the "normal" region of the spectrum. The ultraviolet spectrum of V was very similar to that of the parent indenoquinoline II, having the same shaped band-envelope and type of fine structure. This spectral evidence clearly indicates the structure of V to be a tertiary carbinol rather than a ketodihydroquinoline.

Even with an organometallic reagent with increased steric requirements—*e.g.*, mesitylithium—only the normal 1,2-addition to produce the tertiary carbinol VI was observed as indicated by a study of the absorption spectra of the addition product. Thus there appears to be no tendency for organometallic reagents to add to the heterocyclic ring or undergo a 1,4-conjugate addition with ketone III. This may be a consequence of some resistance to the introduction of an additional double bond into the five-membered ring.

Using the Meerwein-Ponndorf reduction conditions, ketone III was reduced smoothly to the colorless secondary alcohol VII which showed ultraviolet and infrared absorption spectra as expected

(3)(a) N. H. Cromwell and J. C. David, *J. Am. Chem. Soc.*, 82, 1138 (1960); (b) *J. Am. Chem. Soc.*, 82, 2046 (1960).

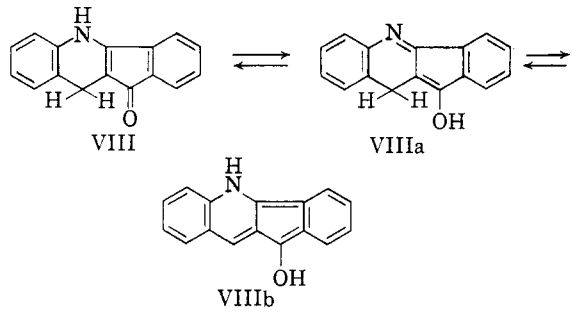
(4) R. C. Fuson and J. J. Miller, *J. Am. Chem. Soc.*, 79, 3477 (1957).

(5) E. Noelting and A. Herzbaum, *Ber.*, 44, 2585 (1911).

for an 11-hydroxy derivative of the parent indenoquinoline II.

Catalytic hydrogenation of the ketone III generally produced mixed products and tenacious absorption of some of them as well as the starting material on the catalyst was bothersome. With larger ratios of catalyst to ketone, 10% palladium on charcoal and hydrogen at three atmospheres pressure caused two molar equivalents of hydrogen to add and the structure of the product, 4a,5,10,10a-tetrahydro-11*H*-indeno[1,2-*b*]quinolin-11-one (IX), has been assigned on the basis of its ultraviolet and infrared absorption spectra. Thus IX shows a carbonyl stretching band at 1707 cm.$^{-1}$, in the region of the infrared spectrum expected for a 1-indanone,[6] and an N—H absorption at 3430 cm.$^{-1}$ Moreover, the ultraviolet spectrum of IX was nearly superimposable with that of 1-indanone.[6]

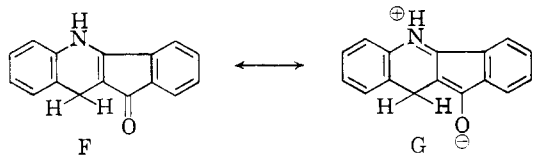
With a lower ratio of the palladium on charcoal catalyst to ketone or with platinum oxide catalyst, a mixture resulted which was made up of the colorless secondary alcohol VII along with a deep burgundy colored crystalline product which absorption spectral and chemical studies indicates is 5,10-dihydro-11*H*-indeno[1,2-*b*]quinolin-11-one (VIII) and/or its tautomeric enol (VIIIa or VIIIb). When the



VIII VIIIa VIIIb

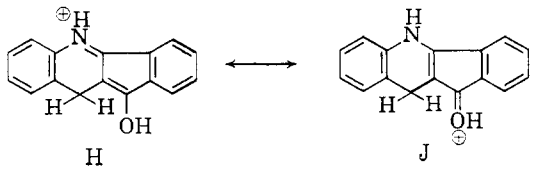
burgundy colored product VIII/VIIIa/VIIIb was heated in benzene solution or irradiated with ultraviolet light, it readily gave up hydrogen to produce the starting ketone III. This burgundy colored product showed spectral characteristics quite foreign to those of the parent compounds, the indenoquinoline II and the keto indenoquinoline III (see Figs. 1 and 2).

In neutral methanol solution (Fig. 3) the absorption of visible range light by VIII at 488 mμ is ascribed to the electronic transition, F ⟷ G, ex-



F G

pected for β-amino-α,β-unsaturated ketones.[3b] The ultraviolet spectrum of the burgundy colored compound in 0.1*N* methanolic hydrogen chloride (Fig. 5) exhibited a slight bathochromic shift with some loss in intensity which may be ascribed to an unrelated electronic transition, H ⟷ J, for the cation



H J

(6) A. Hassner and N. H. Cromwell, *J. Am. Chem. Soc.*, **80**, 893 (1958).

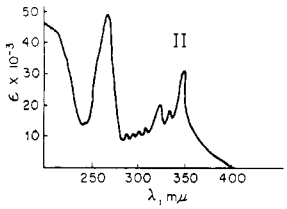


Fig. 1. In methanol

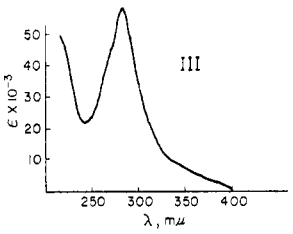


Fig. 2. 0.1*N* $NaOCH_3$ in methanol

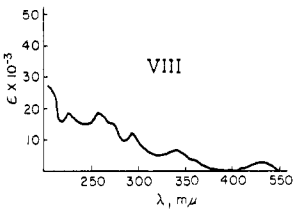


Fig. 3. In neutral methanol

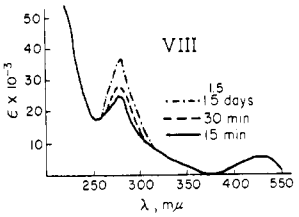


Fig. 4. 0.1*N* $NaOCH_3$ in methanol

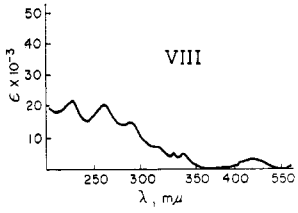


Fig. 5. 0.1*N* methanolic HCl

of the hydrochloride salt of the enol VIIIa of VIII in which no separation of charge or loss of aromaticity is involved.[3b] The basic solution spectrum of VIII is interesting, in that it strongly suggests that a slow dehydrogenation to the parent ketone III occurs in this medium (see Fig. 4).

The solid state infrared spectrum of VIII shows a band at 3240 cm.$^{-1}$ in the intermolecular N—H hydrogen-bonded area. It also shows a band at 3400 cm.$^{-1}$ in the free N—H area and considerable absorption in the 1496–1700 cm.$^{-1}$ region with bands at 1700, 1660, 1620, 1600, 1579, 1542, and 1496 cm.$^{-1}$, with the most intense band at 1542 cm.$^{-1}$ Assignment of bands under these circumstances would be extremely difficult; however, the carbonyl stretching frequencies may be assigned to the bands at 1700 and 1660 cm.$^{-1}$ On the basis of these preliminary studies it is suggested that the burgundy colored material exists as a tautomeric mixture of VIII $\rightleftharpoons$ VIIIa and/or VIIIb.

To compare the reactivity of the methylene group in the 11-position of the indenoquinoline II with that in the benz[*b*]acridine (B), compound II was treated with *N*-bromosuccinimide and found to give a good yield of the desired product, 11-bromo-11*H*-indeno[1,2-*b*]quinoline (X). The bromo compound X was readily converted to the morpholine (XI) and piperidine (XII) derivatives desired for biological testing. The structures of X, XI, and XII are clearly indicated by a comparison of their ultraviolet absorption spectra with that of the parent indenoquinoline II.

The *N*-oxide XIII of II was readily obtained by employing hydrogen peroxide in glacial acetic acid. The identity of this useful amine oxide was established by an infrared absorption spectrum location of the $N^+—O^-$ stretching frequency[7] at 1337 cm.$^{-1}$ A chemical test for *N*-oxides, reported by Coats and Katritzky,[8] indicated the function to be present in XIII.

The availability of the *N*-oxide XIII will allow for the development of a series of reactions which are typical for such substances.[7] In the present investigation the *N*-oxide XIII was found to react with phosphorus oxychloride to remove the *N*-oxide function and chlorinate the 10-position to produce the chloro product XIV in a manner analogous to the behavior of quinoline oxides which are chlorinated in the γ-position when the α-position is blocked.[9,10] The ultraviolet spectra of II and XIV were quite similar.

6 - Chloro - 11*H* - indeno[1,2 - *b*]quinolin - 10 - carboxylic acid (XV) was synthesized by the Pfitzinger-Borsche reaction of 7-chloroisatin with 1-indanone to make it available for comparison of its biological activity with the known drug 8-chloroisotetraphan.[11] The ultraviolet spectra of the carboxylic acids I and XV as measured in a solution of 150 mg. of potassium hydroxide in 100 ml. of methanol were quite similar.

EXPERIMENTAL[12]

11H-Indeno[1,2-b]quinolin-10-carboxylic acid (I). This compound was obtained in 81.5% yield by the procedure of Noelting and Herzbaum[5] as a colorless solid, m.p. 330° dec.; λ_{max} (methanol and potassium hydroxide) 215, 227 (sho.), 258 (sho.), 265, 314, 328, 343 mμ ($\epsilon \times 10^{-3}$ 28.1, 23.9, 30.0, 38.6, 12.8, 16.9, 21.4).

11H-Indeno[1,2-b]quinoline (II). (a) *Decarboxylation of I.* A mixture of 5.0 g. of I and a small amount of copper powder was heated in diethylene glycol at reflux for 2.5 hr. A 43.8% return of the acid I was realized along with a 14% yield of II, after charcoal treatment and recrystallization from ethanol; m.p. 168–170°[5]; λ_{max} 211, 223 (sho.), 263, 300, 307, 313, 320, 328, 335, 343 mμ ($\epsilon \times 10^{-3}$ 47.7, 28.3, 50.4, 7.3, 8.3, 11.6, 13.6, 22.0, 17.6, 32.0).

(b) *From o-aminobenzaldehyde and 1-indanone,* II was obtained by the method of Ruhemann and Levy[13] in a 55% yield, m.p. 167–169°.

11H-Indeno[1,2-b]quinolin-11-one (III).[5] The ketone was prepared by the thermal decarboxylation of 10-carboxy-11*H*-indeno[1,2-*b*]quinolin-11-one[5] on heating to 300–320° for 1 hr. Recrystallization from ethanol and sublimation at 180°/2 mm. gave a 75% yield of pure product, m.p. 175–176°; λ_{max} 215, 220, 226, 240 (sho.), 250 (sho.), 286 mμ ($\epsilon \times 10^{-3}$ 23.3, 24.0, 24.0, 17.7, 18.0, 57.4); $\gamma_{C=O}$ 1723/94, $\gamma_{C=N}$ 1632/91, measured in carbon tetrachloride solution.

Ketone III was obtained in a 16% yield when equal molar amounts of *o*-aminobenzaldehyde and 1,3-indandione were warmed gently with 5% ethanolic potassium hydroxide. Boiling these two reactants in 2*N* hydrochloric acid precipitated the hydrochloride salt of III which was converted to a 60% yield of III on treatment with 4*N* sodium hydroxide solution.

11-Hydroxy-11-methyl-11H-indeno[1,2-b]quinoline (IV). A 2.31-g. (0.01 mole) sample of the ketone III was stirred for 30 min. with 6.5 ml. (0.02 mole) of commercial 3*M* methylmagnesium bromide and the reaction mixture decomposed with cold ammonium chloride solution to produce 2.10 g. (85% yield) of IV; m.p. 202–203°, recrystallized from a dioxane-water solution; λ_{max} 210, 216 (sho.), 226, 261, 310, 317, 324, 331, 339, 347 mμ ($\epsilon \times 10^{-3}$ 37.0, 31.7, 27.0, 33.0, 7.0, 7.2, 9.0, 18.0, 12.7, 23.0); infrared bands (potassium bromide pellet), $\gamma_{bonded\ OH}$ 3180/85, $\gamma_{C=N}$ 1628/73, (methylene chloride solution), γ_{OH} 3560/22, $\gamma_{bonded\ OH}$ 3300/14 (broad), $\gamma_{C=N}$ 1630/40.

Anal. Calcd. for $C_{17}H_{13}NO$: C, 82.57; H, 5.29; N, 5.67. Found: C, 82.52; H, 5.15; N, 5.72.

(7) A. R. Katrizky, *Quart. Rev.*, **10**, 395 (1956), reports the *N*-oxide stretching mode occurs at 1300–1200 cm.$^{-1}$; however, alkyl substituents in the 3- position of pyridine cause a shift toward higher frequencies.

(8) N. A. Coats and A. R. Katritzky, *J. Org. Chem.*, **24**, 1836 (1960).

(9) H. Gilman *et al.*, *J. Am. Chem. Soc.*, **66**, 621 (1944); **68**, 979, 2017 (1946).

(10) G. B. Bachman and D. E. Cooper, *J. Org. Chem.*, **9**, 302 (1944).

(11) J. Braun *et al.*, *Ann.*, **451**, 1 (1926).

(12) Melting points were read with a calibrated thermometer. Ultraviolet absorption spectra were determined with a Cary Model 11-MS recording spectrophotometer using reagent grade methanol solutions. Infrared spectra were measured with a Perkin-Elmer Model 21 double beam recording instrument employing sodium chloride optics and matched sodium chloride cells with indicated solvents unless otherwise stated.

(13) S. Ruhemann and S. I. Levy, *J. Chem. Soc.*, **103**, 551 (1913).

When 0.247 g. of IV was heated at reflux with 0.246 g. of chloranil in 50 ml. of benzene for 12 hr., 88% of the starting carbinol was recovered unchanged.

11-Hydroxy-11-phenyl-11H-indeno[1,2-b]quinoline (V). (a) *From phenylmagnesium bromide.* A 1.16 - g. (0.005 mole) sample of ketone III was refluxed for 1.5 hr. with an ether solution containing about 0.012 mole of phenylmagnesium bromide and worked up to produce 0.56 g. (36.4% yield) of carbinol V, m.p. 261–262°, recrystallized from benzene-petroleum ether; λ_{max} 210, 220 (sho.), 258, 311, 319, 327, 334, 342, 350 mμ ($\epsilon \times 10^{-3}$ 42.7, 36.7, 35.0, 6.0, 8.0, 8.3, 16.3, 24.3); infrared bands (potassium bromide pellet) $\gamma_{bonded\ OH}$ 3140/54, $\gamma_{C=N}$ 1625/51, (saturated chloroform solution, 1.0 mm. cell), γ_{OH} 3600/25, $\gamma_{C=N}$ 1632/22.

Anal. Calcd. for $C_{22}H_{15}NO$: C, 85.44; H, 4.88; N, 4.53. Found: C, 85.33; H, 5.03; N, 4.66.

(b) *From phenyllithium.* Treatment of 1.16 g. (0.005 mole) of ketone III with an ether solution containing 0.012 mole of phenyllithium by reflux over 1.5 - hr. period produced 1.16 g. (75% yield) of the carbinol V, m.p. 260–262°, as colorless needles from benzene and petroleum ether.

11-Hydroxy-11-mesityl-11H-indeno[1,2-b]quinoline (VI). The ketone III, 1.74 g. (0.0075 mole), in 150 ml. of 50% ether-benzene was stirred for 7 hr. with mesityllithium (0.022 mole) to give 1.37 g. (52% yield) of carbinol VI, m.p. 248–249.5°, recrystallized from benzene; λ_{max} 212, 260. 314 (sho.), 320, 328 (sho.), 335, 343, 351 mμ ($\epsilon \times 10^{-3}$ 54.4, 26.0, 7.7, 9.0, 9.0, 16.3, 11.0, 23.3); infrared bands (12 mg./ml. of methylene chloride in 1.0 mm. cell), γ_{OH} 3560/28, $\gamma_{bonded\ OH}$ 3250/30 (broad), $\gamma_{C=N}$ 1625/62.

Anal. Calcd. for $C_{25}H_{21}NO$: C, 85.44; H, 6.02; N, 3.99. Found: C, 85.30; H, 6.01; N, 4.03.

11H-Indeno[1,2-b]quinolin-11-ol (VII). The ketone III was reduced to the secondary alcohol by means of the general Meerwein-Ponndorf reduction, as outlined by Truett and Moulton,[14] with one modification. Hydrochloric acid[15] was used to hydrolyze the complex. A mixture of 1.0 g. (0.0043 mole) of 11*H*-indeno[1,2-*b*]quinolin-11-one (III), 4.4 g. (0.0215 mole) of aluminum isopropoxide and 75 ml. of isopropyl alcohol was heated at reflux for 5 hr. The reaction mixture was then evaporated to a volume of 8 ml., hydrolyzed with 35 ml. of concd. hydrochloric acid in 175 ml. of water, and allowed to stand for 8 hr. The pale yellow colored hydrochloride salt was filtered and treated with 5% sodium bicarbonate to produce the colorless carbinol VII; wt. 0.91 g. (91.0% yield), m.p. 226–228°, recrystallized from ethanol after charcoal treatment; λ_{max} 216, 227 (sho.), 262, 316, 323, 330, 338, 345 mμ ($\epsilon \times 10^{-3}$ 33.3, 27.0, 36.0, 10.6, 11.0 19.0, 14.3, 27.6); infrared bands (potassium bromide pellet), $\gamma_{bonded\ OH}$ 3200/87, $\gamma_{C=N}$ 1625/84, (saturated chloroform solution in 1.0 mm. cell), γ_{OH} 3560/12, $\gamma_{bonded\ OH}$ 3360–3000/17, $\gamma_{C=N}$ 1635/32.

Anal. Calcd. for $C_{16}H_{11}NO$: C, 82.38; H, 4.75; N, 6.01. Found: C, 82.40; H, 4.84; N, 5.88.

Catalytic hydrogenation of 11H-indeno[1,2-b]quinolin-11-one (III). (a) *Palladium on charcoal (1.0 g./1.16 g. of III).* A suspension of 1.16 g. (0.005 mole) of ketone III and 1.0 g. of 10% palladium on charcoal in 110 ml. of benzene was shaken in the Parr hydrogenation apparatus under 45 p.s.i. of hydrogen for 3.5 hr. Removal of the catalyst, charcoal treatment, and evaporation of the benzene filtrate left a brown colored oil. Treatment with methanol gave 0.22 g. (19.0% yield) of straw colored crystals, m.p. 140–143°. A recrystallization from methanol gave colorless plates of 4a,5,10,10a-tetrahydro-11*H*-indeno[1,2-*b*]quinolin-11-one (IX); λ_{max} 241, 283 mμ ($\epsilon \times 10^{-3}$ 20.3, 4.0); infrared bands (hexachlorobutadiene mull), γ_{NH} 3430/50, $\gamma_{C=O}$ 1707/71, $\gamma_{ArC=C}$ 1612/46.

Anal. Calcd. for $C_{16}H_{13}NO$: C, 81.68; H, 5.57; N, 5.95. Found: C, 81.59; H, 5.66; N, 5.81.

Extraction of the palladium on charcoal catalyst with ethanol gave 0.20 g. (17.2% recovery) of the ketone III. Further extractions with hot ethanol, acidic methanol, and chloroform afforded only intractable brown residues.

(b) *Palladium on charcoal (0.4 g./1.16 g. of* III). A suspension of 0.4 g. of 10% palladium on charcoal in a solution of 1.16 g. (0.005 mole) of III in 90 ml. of benzene was shaken under 45 p.s.i. of hydrogen for 3 hr. Filtration of the reaction mixture resulted in a yellow benzene filtrate which was reduced in volume and cooled to give 0.32 g. of a tan solid. Recrystallizations from benzene, methanol-water, and isopropanol-water resulted in a colorless solid, 11*H*-indeno[1,2-*b*]quinolin-11-ol (VII), wt. 0.30 g. (26% yield), m.p. 220–223°. A mixed melting point experiment with authentic VII showed no depression. Complete evaporation of the benzene filtrate gave a yellow colored solid which was for the most part unchanged ketone III.

A deep burgundy colored solution was obtained by extraction of the palladium on charcoal catalyst with 95% ethanol. Reduction in volume and cooling gave 0.21 g. (18.1% yield) of deep burgundy colored needles (VIII), m.p. 215–221° (instantaneous m.p. 228–229.5°; the red colored melt turns yellow at 240–250°); λ_{max} 226, 263, 286, 310 (sho.), 330, 345 (sho.), 488 mμ ($\epsilon \times 10^{-3}$ 22.7, 20.8, 14.6, 8.8, 6.4, 5.8, 4.5); infrared bands (potassium bromide pellet) $\gamma_{OH/NH}$ 3400/34, 3240/43, $\gamma_{C=O}$ 1700/25, 1660/37, $\gamma_{unassigned}$ 1620/51, 1600/59, 1579/51, 1542/67, 1496/62.

Anal. Calcd. for $C_{16}H_{11}NO$: C, 82.38; H, 4.75; N, 6.01. Found: C, 82.22; H, 4.82; N, 5.77.

When a small sample of the burgundy colored solid was dissolved in benzene and irradiated with ultraviolet light or heated at reflux for a short period of time, the deep red solution turned yellow in color. Evaporation of the yellow colored filtrate and recrystallization of the residue from aqueous methanol gives straw colored needles, m.p. 175–176°. A mixed melting point experiment with authentic ketone III showed no depression.

(c) *Platinum oxide.* To a solution of 1.09 g. (0.005 mole) of III in 125 ml. of benzene was added 0.1 g. of platinum oxide. The resulting slurry was shaken for 5 hr. under 45 p.s.i. of hydrogen. At the end of this time, the walls of the reaction vessel were coated with a burgundy colored solid. Filtration of the catalyst followed by extraction with 95% ethanol gave a deep burgundy colored solution which yielded 0.12 g. (17.4% yield) of VIII, m.p. 218–223°, on evaporation of the solvent. The benzene reaction medium was also evaporated to dryness and the residue recrystallized several times from benzene, from which 0.35 g. (32.1% yield) of carbinol VII was obtained, m.p. 221–224°.

11-Bromo-11H-indeno[1,2-b]quinoline (X). A mixture of 7.23 g. (0.033 mole) of the indenoquinoline II, 50 mg. of benzoyl peroxide and 12.3 g. (0.033 mole) of *N*-bromosuccinimide in 150 ml. of carbon tetrachloride was heated at reflux for 4 hr., after which the heavy *N*-bromosuccinimide had changed completely to the light succinimide. The mixture was cooled and filtered, and evaporated to an oily residue. The crude product was dissolved in acetone at room temperature and treated with charcoal overnight. Dilution with water gave X; wt. 7.21 g. (73.3% yield), m.p. 139–140°, recrystallized from aqueous acetone; λ_{max} 215, 265, 316, 323, 331, 338, 347 mμ ($\epsilon \times 10^{-3}$ 31.6, 35.7, 8.3, 8.0, 11.0, 9.3, 14.3).

Anal. Calcd. for $C_{16}H_{10}NBr$: C, 64.88; H, 3.40; Br, 26.99. Found: C, 65.58; H, 3.63; Br, 26.60.

11-Morpholino-11H-indeno[1,2-b]quinoline (XI). (a) *In carbon tetrachloride solvent.* To the carbon tetrachloride solution of the bromide X, prepared from 1.9 g. (0.00875 mole) of II, 1.56 g. (0.00875 mole) of *N*-bromosuccinimide and a trace of benzoyl peroxide was added 3 ml. of morpholine. The mixture was refluxed for 2 hr., after which the morpholine hydrobromide was removed and the filtrate washed with water. The red oil which resulted from evaporation was dissolved in ethanol, treated with charcoal and diluted with water. A recrystallization from aqueous ethanol gave

(14) W. L. Truett and W. N. Moulton, *J. Am. Chem. Soc.*, **73**, 5913 (1951).

(15) A. L. Wilds, *Org. Reactions*, **2**, 178 (1944).

1.0 g. (38% yield) of XI, m.p. 154–156°; λ_{max} 215, 225 (sho.), 264, 316, 323 (sho.), 330, 338, 346 mμ ($\epsilon \times 10^{-3}$ 37.0, 28.3, 41.4, 10.0, 11.0, 16.0, 12.7, 20.0).

(b) *In excess morpholine.* A solution of 0.74 g. (0.0025 mole) of X in 15 ml. of morpholine was heated at reflux for 23 hr., and poured into 300 ml. of water. A recrystallization of the crude product from benzene-petroleum ether, with charcoal treatment, gave 0.48 g. (64% yield) of XI as colorless needles, m.p. 155–156°.

Anal. Calcd. for $C_{20}H_{18}N_2O$: C, 79.47; H, 5.96; N, 9.27. Found: C, 79.25; H, 6.09; N, 9.13.

11-Piperidino-11H-indeno[1,2-b]quinoline (XII). Fifteen milliliters of redistilled piperidine and 0.74 g. (0.0025 mole) of the bromide X were refluxed for 23 hr., after which the mixture was poured into 500 ml. of water to give 0.56 g. (80.0% yield) of a colorless solid, m.p. 139–140° (colorless needles from petroleum ether); λ_{max} 215, 225 (sho.), 264, 316, 323 (sho.), 330, 338, 346 mμ ($\epsilon \times 10^{-3}$ 37.0, 28.3, 41.4, 10.0, 11.0, 16.0, 12.7, 20.0).

Anal. Calcd. for $C_{21}H_{20}N_2$: C, 83.96; H, 6.71; N, 9.33. Found: C, 83.89; H, 6.67; N, 9.66.

11H-Indeno[1,2-b]quinolin 1-oxide (XIII). A solution of 1.09 g. (0.005 mole) of the indenoquinoline II and 0.7 ml. of 30% hydrogen peroxide in 15 ml. of glacial acetic acid was heated at 69–70° for 3 hr., after which an additional 0.3 ml. of 30% hydrogen peroxide was added. After 17 hr. at 69°, a gold colored solid, XIII, wt. 0.99 g. (85.0% yield), was obtained by evaporation of the reaction medium under vacuum. A 0.200-g. sample of XIII was triturated with 10% sodium hydroxide, extracted with chloroform, dried and evaporated. Recrystallization of the residue from benzene gave 160 mg. of XIII as yellow plates, m.p. 216–219° dec.; λ_{max} 226, 270, 278, 306, 322, 339, 355 mμ ($\epsilon \times 10^{-3}$ 29.7, 15.0, 15.2, 4.2, 3.7, 4.4, 4.0); infrared bands (saturated chloroform solution, 1.0 mm. cell), $\gamma_{C=N}$ 1625/32, $\gamma_{ArC=C}$ 1610/29, γ_{N-O} 1337/55.

Anal. Calcd. for $C_{16}H_{11}NO$: C, 82.38; H, 4.75; N, 6.01. Found: C, 82.36; H, 4.68; N, 6.04.

Compound XIII gives a deep blue coloration,[8] as a positive *N*-oxide test, upon boiling a sample with dimethylaniline and hydrochloric acid, followed by ethanol addition to the cooled solution.

10-Chloro-11H-indeno[1,2-b]quinoline (XIV). 11*H*-Indeno[1,2-*b*]quinolin 1-oxide (XIII) was chlorinated, presumably in the *para* position, *via* the procedure of Bachman and Cooper.[10] To 3 ml. of phosphorus oxychloride, chilled in ice, was added in portions, 0.5 g. (0.00215 mole) of the *N*-oxide XIII. After the addition was complete, the mixture was warmed gently under a condenser until refluxing began and continued for 45 min., at the end of which time solution was complete. The dark colored mixture, after cooling, was poured, with stirring, onto 15 g. of crushed ice. The oil which appeared initially, slowly solidified with stirring and scratching. The hydrochloride salt was collected and dried. Dissolving this product in a minimum amount of methanol and neutralizing to *p*H 8 with dilute ammonium hydroxide afforded pale tan colored needles of XIV. Recrystallization from aqueous acetone at room temperature gave 0.24 g. (44.5% yield) of an almost colorless solid, m.p. 152–153.5°; λ_{max} 215, 265, 314, 321, 329, 336, 344 mμ ($\epsilon \times 10^{-3}$ 37.6, 49.2, 11.5, 10.6, 17.1, 11.5, 23.6).

Anal. Calcd. for $C_{16}H_{10}NCl$: C, 76.34; H, 4.00; N, 5.57. Found: C, 76.07; H, 3.98; N, 5.69.

6-Chloro-11H-indeno[1,2-b]quinoline-10-carboxylic acid. (XV). The Pfitzinger-Borsche reaction was employed, using 0.66 g. (0.005 mole) of 1-indanone and 1.09 g. (0.006 mole) of 7-chloroisatin in a solution of 1.5 g. of sodium hydroxide in 20 ml. of water. A treatment of the sodium salt with hot 25% acetic acid gave 0.85 g. (57.6% yield) of XV, as a tan powder; m.p. 284–287° dec. (recrystallized from acetone); λ_{max} (methanol and potassium hydroxide) 215, 260 (sho.), 269, 318 (sho.), 330, 345 mμ ($\epsilon \times 10^{-3}$ 36.4, 34.7, 51.5, 11.9, 16.5, 18.8); infrared bands (potassium bromide pellet) γ_{OH} 3400/39, γ_{COOH} 1722/73, $\gamma_{C=N}$ 1622/57.

Anal. Calcd. for $C_{17}H_{10}NO_2Cl$: C, 6 .0 ; H, 3.41; Cl, 11.99. Found: C, 69.10; H, 3.47; Cl, 12.21.

Acknowledgment. The work described here was supported in part by Research Grant CY 2931 from the National Cancer Institute, U. S. Public Health Service.

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[CONTRIBUTION FROM AVERY LABORATORY, UNIVERSITY OF NEBRASKA]

Indenoquinolines. II.[1a] Derivatives of 6*H*-Indeno(2,1-*b*)quinoline

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Received March 8, 1961

6*H*-Indeno(2,1-*b*)quinolin-6-one (II) adds Grignard reagents and is catalytically reduced in a 1,2-fashion to produce carbinols. 6*H*-Indeno(2,1-*b*)quinoline (I) reacted with *N*-bromosuccinimide to produce the 6,6-dibromo derivative which was hydrolyzed to II. Attempts to prepare the *N*-oxide of I also produced II. The indenoquinoline I reacts with dimethyl sulfate to give a 5-methosulfate derivative which in turn reacts with aqueous base to produce the pseudo-azulene or anhydronium base, 5-methyl-5*H*-indeno(2,1-*b*)quinoline.

As a part of a program to develop the chemistry of the indenoquinolines[1a] in a search for new types of polycyclic heterocyclic compounds of biological interest,[2] reactions of the little studied 6*H*-indeno(2,1-*b*)quinoline analogous to those studied for 11*H*-indeno(1,2-*b*)quinoline[1a] (A) have been investigated.

6*H*-Indeno(2,1-*b*)quinoline (I) was obtained in adequate amounts by the condensation of *o*-aminobenzaldehyde and 2-indanone following the procedure reported by Clemo and Felton.[3] Several

(1)(a) For paper I in this series see N. H. Cromwell and R. A. Mitsch, *J. Org. Chem.*, 26, 3812 (1961). (b) U. S. Public Health Fellow, 1958–1960, National Institute of Allergy and Infectious Diseases.

(2) For new derivatives in the benz(c)acridine series, see (a) V. L. Bell and N. H. Cromwell, *J. Org. Chem.*, 23, 789 (1958) and (b) N. H. Cromwell and V. L. Bell, *J. Org. Chem.*, 24, 1077 (1959); for benz(b)acridines, see (c) N. H. Cromwell and J. C. David, *J. Am. Chem. Soc.*, 82, 1138 (1960) and (d) *J. Am. Chem. Soc.*, 82, 2046 (1960).

(3) G. R. Clemo and D. G. Felton, *J. Chem. Soc.*, 1658 (1952).