Nicotinyl-D-phenylalaninamide (VI).—To a solution of 0.54 g. of nicotinyl-DL-phenylalaninamide[18] in 200 ml. of water containing 5 ml. of 0.5 *M* tris-(hydroxymethyl)-aminomethane–hydrochloric acid buffer was added 50 mg. of α-chymotrypsin and the reaction mixture maintained at 25° for 2 days. The solution was then evaporated *in vacuo* to 60 ml. and the crystalline precipitate collected to give 0.20 g. of VI, fine long needles, m.p. 187°, after recrystallization from water, $[\alpha]^{26}D$ +37 ± 1° (*c*, 1% in methanol).

Anal. Calcd. for $C_{15}H_{15}O_2N_3$ (269): C, 66.9; H, 5.6; N, 15.6. Found: C, 66.7; H, 5.7; N, 15.7.

Nicotinyl-L-phenylalanine (VII).—The mother liquor remaining after the isolation of VI was acidified with *N* hydrochloric acid and evaporated to dryness *in vacuo*. The residue was extracted with acetone, the acetone extract evaporated to dryness, the residue induced to crystallize by rubbing with water and the product recrystallized twice from water to give 0.12 g. of VII, stunted needles, m.p. 177–178°, $[\alpha]^{26}D$ −45 ± 1° (*c*, 0.67% in methanol).

Anal. Calcd. for $C_{15}H_{14}O_3N_2$ (270): C, 66.7; H, 5.2; N, 10.4. Found: C, 66.4; H, 5.3; N, 10.2.

Enzyme Experiments.—The methods used were identical with those described previously.[3] All experiments were conducted at 25° and *p*H 7.9 in aqueous solution 0.02 *M* in respect to the amine component of a tris-(hydroxymethyl)-aminomethane–hydrochloric acid buffer. The K_I values given in Table I are based upon the following K_S values, acetyl-L-tryptophanamide, 5.3[3]; nicotinyl-L-tryptophanamide, 2.7[3]; acetyl-L-tyrosinamide, 30.5[9]; nicotinyl-L-tyrosinamide, 15.0,[20] all × 10^{-3} *M*. In the experiments where acetyl-L-tryptophanamide was used as a substrate[3] it was shown that the experimental conditions were such as to permit the reaction to proceed under zone A conditions.[7,8] From the data given in Figs. 1–4 it can be shown that this is also true for all of the experiments reported in this communication. The α-chymotrypsin used in this study was an Armour preparation, lot no. 90402, of bovine origin.

(20) This value is based upon unpublished data obtained in these laboratories by R. V. MacAllister, D. W. Thomas and H. T. Huang. An account of this work will be given in the near future.

PASADENA 4, CALIF. RECEIVED SEPTEMBER 14, 1950

[CONTRIBUTION FROM THE CONVERSE MEMORIAL LABORATORY OF HARVARD UNIVERSITY]

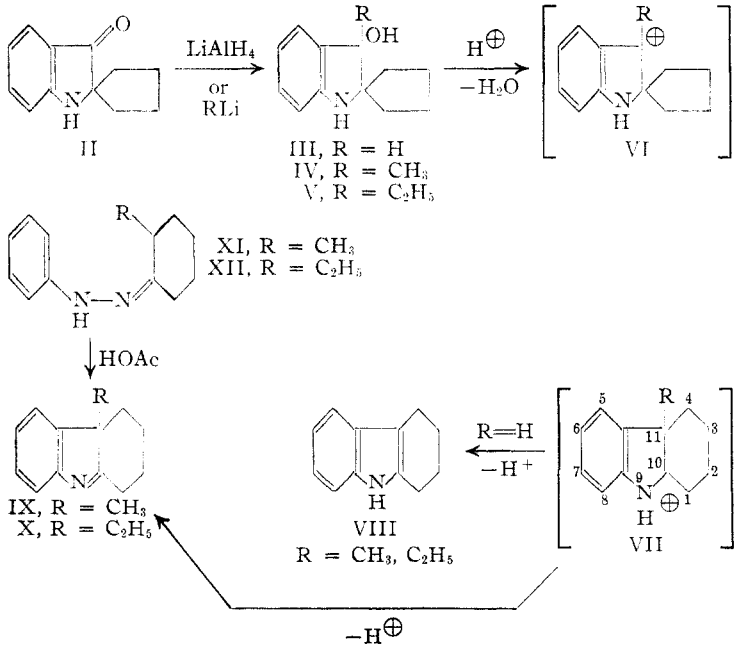
An Unusual Twofold Wagner–Meerwein Rearrangement

BY BERNHARD WITKOP[1] AND J. B. PATRICK[1,2]

Alkyllithium compounds react with *spiro*-(cyclopentane-1,2′-ψ-indoxyl) (II) to give tetrahydrocarbazolenines (IX, X) with angular substituents at position 11. The reaction of II with Grignard reagents leads to *spiro*-(cyclopentane-1,3-ψ-indoles) (XXIII, XXIV) with substituents at position 2 *via* a twofold successive Wagner–Meerwein rearrangement. The intermediate in the latter reaction is 11-hydroxytetrahydrocarbazolenine (I, or the Grignard complex XIX). These differences in the mode of reaction of the two organometallic reagents are discussed in terms of possibly *intra*molecular (lithium) and *inter*molecular (magnesium) rearrangements of the initial coördination complexes (XXX, XXXI).

We have dealt previously with the chemistry[3] and kinetics[4] of the rearrangements of 11-hydroxytetrahydrocarbazolenine under the influence of acids and bases[5] as well as with its important role as an intermediate in the oxidation in general of indole compounds.[6,7] As an extension of these investigations we are describing in this paper the reactions of 11-hydroxytetrahydrocarbazolenine (I) and of *spiro*-(cyclopentane-1,2′-*pseudo* indoxyl) (II) with lithium and magnesium organic reagents. *It was found that II reacts with methyllithium to give the tetrahydrocarbazolenine IX, and with methylmagnesium iodide to yield the indolenine XXIII.*

The reaction of the yellow spiran (II) with alkyllithium would be expected to be analogous to the reduction with lithium aluminum hydride to the colorless alkamine (III)[8] and should lead to the carbinols IV or V. Owing to steric hindrance of the carbonyl group in II and its conjugation with the imino group it is not surprising that about 80 to 90% of II can be recovered from the reaction mixture. In the case of III acid leads to carbonium intermediates VI and VII (R = H), the latter losing a proton at position 11 to yield tetrahydrocarbazole. Likewise, the carbinols IV and V which were not isolated probably underwent reaction through the same intermediates (VI and VII, R = CH_3 and C_2H_5). However, the proton lost from structure VII has to come from the nitrogen atom at position 9. The resulting indolenines, 11-methyl- and 11-ethyltetrahydrocarbazolenines, easily isolable because of their marked basicity, prove to be identical with synthetic



(1) National Heart Institute, Bethesda 14, Md.
(2) Research Corporation Fellow, 1950.
(3) Witkop and Patrick, *Experientia*, **6**, 183 (1950).
(4) Witkop and Patrick, THIS JOURNAL, **73**, 713 (1951).
(5) Patrick and Witkop, *ibid.*, **72**, 633 (1950).
(6) Witkop, *ibid.*, **72**, 1428 (1950).
(7) Witkop, *ibid.*, **72**, 2311 (1950).
(8) Witkop, *ibid.*, **72**, 614 (1950).

specimens prepared according to Plancher[9] and Lions.[10]

When the spiran (II) was added to methyl- or ethylmagnesium iodide the reaction seemed to take the same course and after decomposition of the Grignard complex with acid about 10% of basic compounds were isolated that had the same composition as the indolenines (IX and X) and similar but definitely different physical constants (Table I). The ultraviolet absorption spectra (Figs. 1 and 2, Table II) of the free bases and of

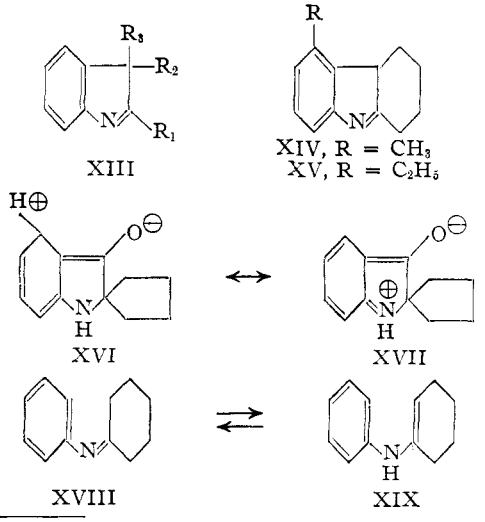
TABLE I

Compound	Picrate M.p., °C.	Picrate Mixed m.p., °C.	Hydrochloride M.p., °C.	Hydrochloride Mixed m.p., °C.
11-Methyltetrahydrocarbazolenine (IX)	173	160–168	166	
spiro-(Cyclopentane-1,3′-*pseudo*-2′-methyldinole) (XXIII)	190		182	
11-Ethyltetrahydrocarbazolenine (X)	148–150	123–130	181	169–181
spiro-(Cyclopentane-1,3′-*pseudo*-2′-ethylindole) (XXIV)	142–144		181–183	

TABLE II

Compound	Free base λmax (log ε)	Free base λmin (log ε)	Hydrochloride λmax (log ε)	Hydrochloride λmin (log ε)
11-Ethyltetrahydrocarbazolenine	257 (3.788)	233 (3.510)	260 (3.758)	233 (3.537)
spiro-(Cyclopentane-1,3′-*pseudo*-2′-ethylindole) (XXIV)	258 (3.772)	236 (3.511)	265 (3.746)	242 (3.654)
2-Isopropyl-3,3-dimethyl-*pseudo*-indole	258 (3.770)	235 (3.499)		

their hydrochlorides suggest the identity, or close similarity, of the light absorbing system. From previous data[11] it is quite clear that the system responsible for these characteristic maxima and minima must in all the cases listed be that of an indolenine (XIII) in which there are only differences with regard to the nature of the substituents R_1, R_2, R_3. Structures XIV and XV were also taken into consideration. They would explain the two different pairs of bases on the principle of 1,2-addition with lithium compounds, and 1,4-addition to structures XVI↔XVII with magnesium



(9) Plancher and Ghigi, *Gazz. chim. ital.*, **59**, 371 (1929).

(10) Lions, *J. Proc. Royal Soc. N. S. Wales*, **71**, 192 (1937).

(11) Witkop and Patrick, THIS JOURNAL, **73**, 713 (1951), Table I and Fig. 4.

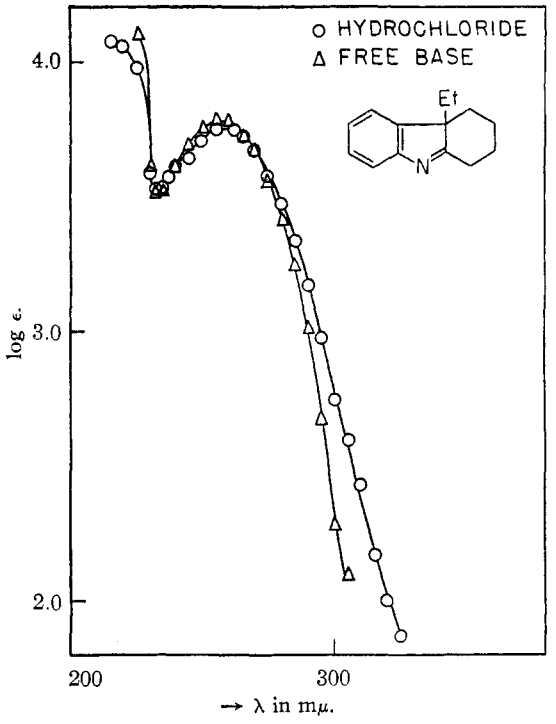


Fig. 1.—Ultraviolet spectrum of 11-ethyltetrahydrocarbazolenine (free base and hydrochloride) in ethyl alcohol.

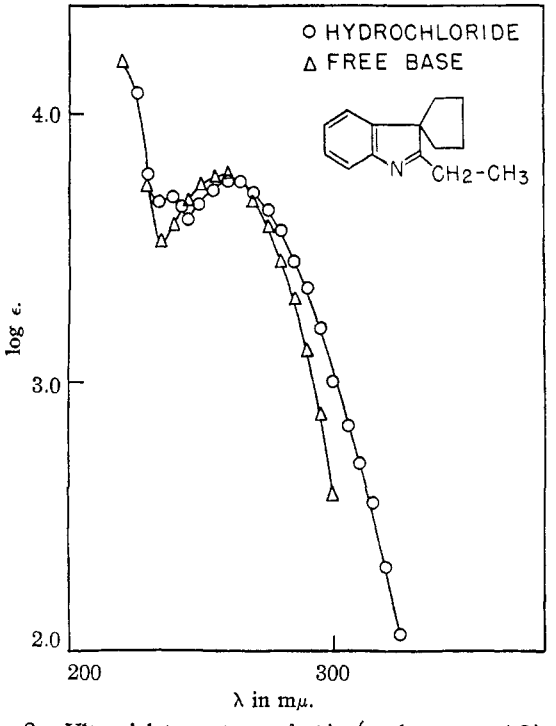


Fig. 2.—Ultraviolet spectrum of *spiro*-(cyclopentane-1,3′-Ψ-2′-ethylindole) (free base and hydrochloride) in ethyl alcohol.

compounds. So far no tautomers of isomeric indoles, such as XIV and XV have been isolated nor would they be expected to be stable, whereas such a tautomerism is much more noticeable with the open cyclohexanone anil (XVIII ⇄ XIX) as we found by study of the infrared absorption spectra. The infrared spectra of the isomeric bases and their hydrochlorides (Fig. 3, A-E) all show the absence

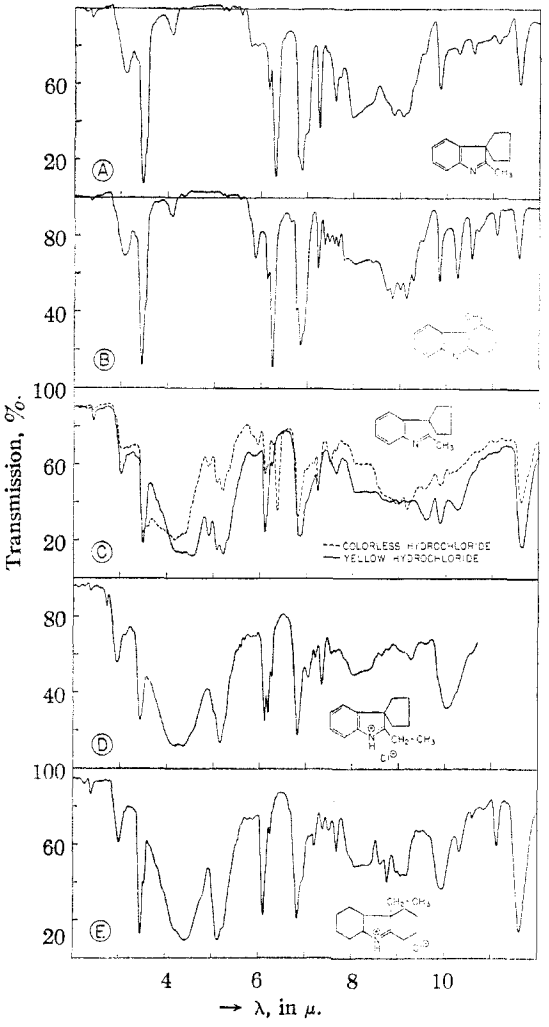
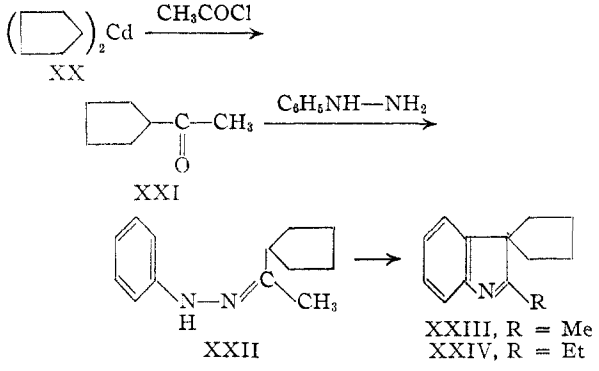


Fig. 3.—Infrared spectra in chloroform.

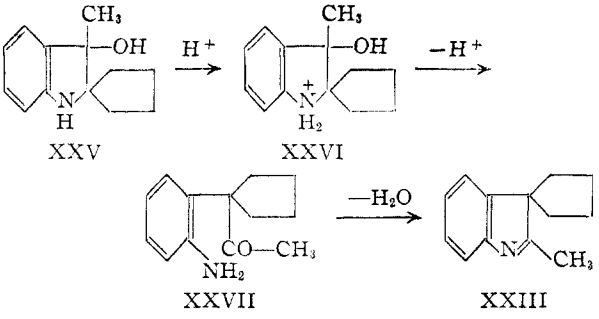
of an indolic NH-band (2.9μ) and the presence of a strong band at 6.10–6.25μ characteristic of anilino structures in general[12] and indolenines in particular.[4,5,8]

We suspected the product resulting from the action of Grignard reagents on II to have the constitution of the indolenine XXIII. This was proved by synthesis.[13] Dicyclopentylcadmium (XX) with acetyl chloride gave methyl cyclopentyl ketone. The phenylhydrazone of the latter on refluxing with glacial acetic acid furnished *spiro* - (cyclopentane - 1,3′ - *pseudo* - 2′ - methylindole)[14] (XXIII) identical with the reaction product of methylmagnesium iodide on *spiro*-(cyclopentane-1,2′-*pseudo*indoxyl) (II).

The change that leads from II to XXIII involves the shifting of a *spiro*-cyclopentane ring from position 2 to position 3 of what is essentially a *pseudo*-indole (indolenine) system. *Prima facie* it is an attractive hypothesis[14a] to regard this double shift as only a single migration by interpretation of the rearrangement in the following way: the only migration occurring in such a sequence would be that of the amino phenyl group from the β-position to the α-position of the indole system. By the



conversion of $>NH \rightarrow >\overset{+}{N}H_2$ (XXV→XXVI), through attack of the proton or analogous magnesium salt complex, the nitrogen could secure the pair of electrons binding it to the α-carbon. Neu-



trality would be achieved by expulsion of the proton from the hydroxy group with subsequent migration of the aromatic substituent. Loss of water from XXVII would lead to the final *spiro*-indolenine XXIII.

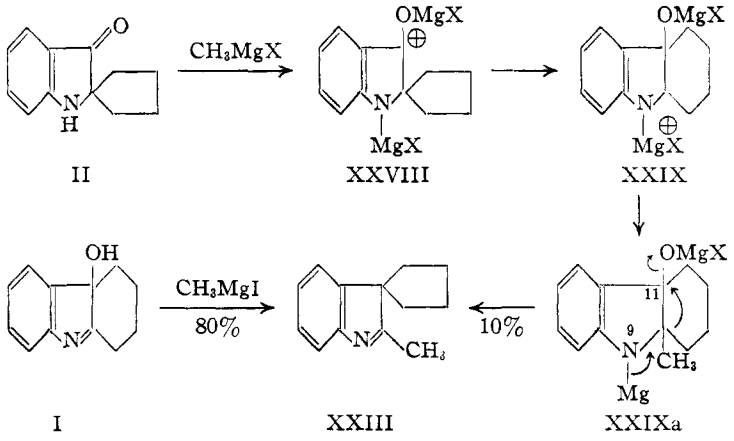
The above scheme became untenable when the same compound XXIII was obtained from 11-hydroxytetrahydrocarbazolenine (I) by the action of methyl Grignard reagent. A reaction mechanism which will account for this observation is as follows: Structure XXVIII is the first intermediate in the interaction of II with excess Grignard reagent. The internal Wagner–Meerwein shift is evidently faster than the external addition of a methyl group. The alkyl group enters at a subsequent stage XXIX. The departing OMgX group (XXIXa) secures the binding pair of electrons from position 11. The second Wagner–Meerwein shift takes place now aided by the electron pull at position 11 and by the electron push at position 9 (XXIXa). Structure XXIX, as one can easily see, is potentially nothing else than 11-hydroxytetrahydrocarbazolenine (I) after the reaction with 2 moles of Grignard reagent. The proof of the reaction mechanism outlined above is the formation

(12) Randall, Fuson, Fowler and Dangl, IR-Determinations of Organic Structures, Table opposite p. 20, New York, 1949; *cf.* Barnes, Gore, Stafford and Williams, *Anal. Chem.*, **20**, 402 (1948); Thompson, *J. Chem. Soc.*, 328 (1948).

(13) Although Hughes and Lions, *J. Proc. Roy. Soc. New South Wales*, **71**, 496 (1938), in the last paragraph of the theoretical part mention their intention of "preparing and examining the indolenine from methyl cyclopentyl ketone," the compound does not seem to have been synthesized so far.

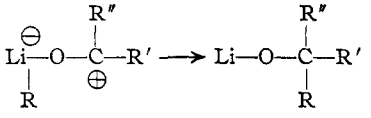
(14) *Cf.* rules for the nomenclature of spirans, *C. A.*, **39**, 5885, 5888 (1945); the name previously employed was 1-cyclopentane-3(2-methylindolenine)-spiran.

(14a) We are greatly obligated to Sir Robert Robinson for kindly pointing out the necessity to consider this type of mechanism.

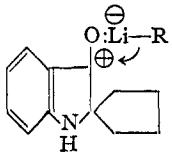


of 80% of indolenine (XXIII) from I with methylmagnesium iodide.

This different mode of action of lithium and Grignard compounds on the spiran II adds another example to the cases in which the two organometallic reagents differ. The work of Swain and Kent[15] would seem to suggest that the first intermediate of the reaction between an alkyl lithium and a ketone may be a coördination complex (fast reaction) that undergoes an ionic, or Wagner–Meerwein type, rearrangement (slow reaction).

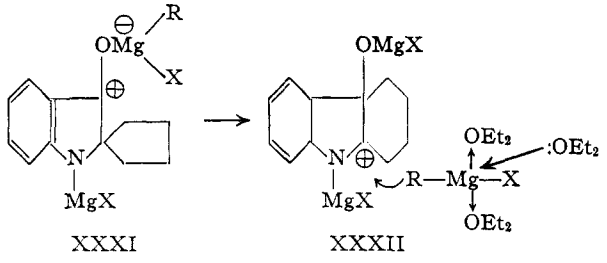


Accordingly, the coördination complex between alkyl lithium and the *spiro*-indoxyl (II) may be represented by structure XXX. The subsequent

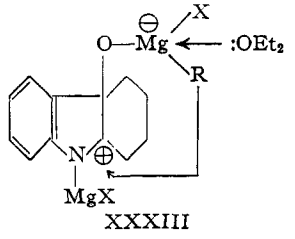


XXX

intramolecular migration of the alkyl group from the lithium to the positive carbon apparently competes successfully with the alternate possibility



XXXI XXXII

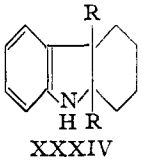


XXXIII

(15) Swain and Kent, THIS JOURNAL, **72**, 518 (1950).

of rearrangement and extension of the cyclopentane. The analogous magnesium complex (XXXI) may not be capable of an internal migration of the alkyl group from the magnesium to the carbon bearing the positive charge. Here rearrangement of the spiran would supervene and the alkyl group then enters by an *intermolecular*[16] mechanism (XXXII). The alternative of an intramolecular rearrangement proceeding through a quasi five-membered ring intermediate is pictured in XXXIII. To what extent additional factors such as differences in reaction rates, considerations of the relative stability of the initial coördination complexes and certain steric requirements with regard to acceptor and donor centers, enter the hypothetical picture is difficult to assess in the absence of further experimental material.

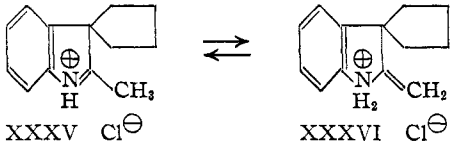
Carbazolenines and Grignard Reagents.—It would seem possible to arrive at 10,11-dialkylhexahydrocarbazoles (XXXIV) by the addition of Grignard reagents to the >C=N double bond of



XXXIV

11-alkyltetrahydrocarbazolenines. However, no such product was isolable from the reactions of 11-ethyltetrahydrocarbazolenine with excess[17] ethyl magnesium iodide, or of 11-methyltetrahydrocarbazolenine with excess methyl lithium. Ordinary indolenines are known to dimerize under the action of Grignard reagents.[18]

Tautomerism of Indolenines and Carbazolenines.—The hydrochloride of *spiro*-(cyclopentane-1,3′-*pseudo*-2′-methylindole) (XXIII) exists in two different isomeric forms, a colorless and a yellow one. Their infrared and ultraviolet spectra are not identical (Figs. 3C, 4). A tautomerism XXXV⇄XXXVI is ruled out by the absence of the



XXXV XXXVI

characteristic >C=CH$_2$-band at 11.35μ in the infrared spectrum.

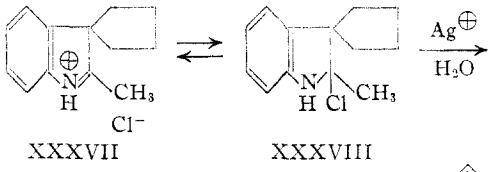
A clue to the nature of the tautomerism is furnished by the behavior of the two hydrochlorides toward aqueous silver nitrate solution: the yellow hydrochloride immediately produces a precipitate of silver chloride without discoloration; the colorless hydrochloride produces a precipitate somewhat

(16) Some leading references on the mechanism of Grignard reactions: Hess and Rheinboldt, *Ber.*, **54**, 2043 (1921); Meisenheimer, *Ann.*, **442**, 180 (1925); Meerwein, *ibid.*, **455**, 227 (1927); Gilman and Jones, THIS JOURNAL, **62**, 1243 (1940); Swain, *ibid.*, **69**, 2306 (1947).

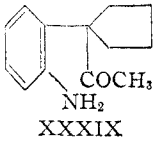
(17) The evolution of gas in these reactions would indicate that the Grignard reagent reacts with the active methylene at position 1.

(18) Plancher and Ravenna, *Atti R. Accad. dei Lincei*, [5] **15**, II, 555 (1906); *Chem. Zentr.*, **78**, I, 107 (1907).

more slowly while the solution turns black on standing owing to the liberation of metallic silver. An interpretation of these changes is pictured in the structures XXXVII to XXXIX.



XXXVII XXXVIII

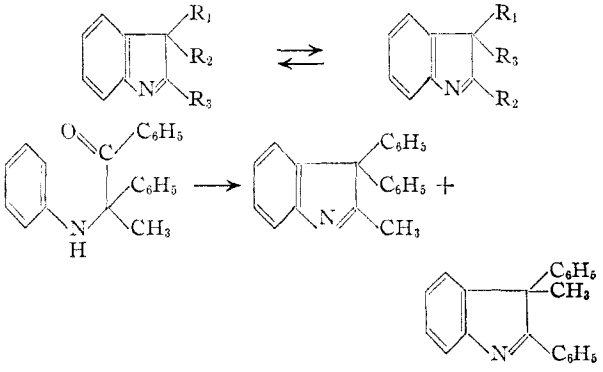


XXXIX

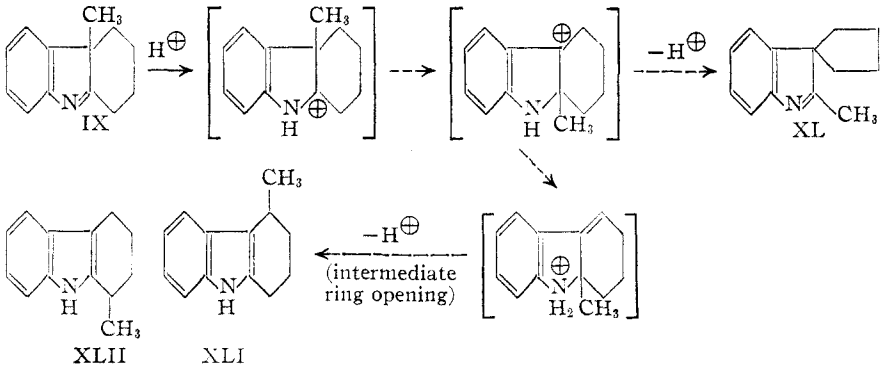
The yellow hydrochloride (XXXVII) contains the chlorine bound ionically; the yellow color may be due to the general bathochromic effect of salt formation observed with certain types of heterocyclic aromatic bases. The colorless hydrochloride contains homopolar chlorine.[19] On solvolysis with aqueous silver nitrate the amino ketone (XXXIX) arises which should reduce silver nitrate solution, owing to the presence of an anilino group.[20]

Similar conditions apparently obtain in the "dimorphism" of the two different methiodides of 11-ethyltetrahydrocarbazolenine (X).[10]

The Plancher Rearrangement.—Migrations of alkyl and aryl groups from position 2 to position 3, and *vice versa*, in indolenines are known as Plancher rearrangements.[21,22,23] More recent work[24] using reactions such as



seems to indicate that not only the migratory aptitudes of the shifting groups are important but also the thermodynamic stability of the rearranged product. We consider the latter instance as the reason for the failure to cause 11-alkyltetrahydrocarbazolenines to rearrange to structures XL and XLI using acidic conditions. Starting from the hydrazone XI the indolenine IX and the indole XLII have been obtained in ratios depending on the strength of the acids used for ring closure.[25] There is no indication for the formation of an isomeric indole XLI. Therefore, the Plancher rearrangement does not help to explain the mechanism of the Fischer indole-indolenine synthesis.



IX XL XLII XLI

Experimental[26]

11-Methyltetrahydrocarbazolenine (IX). A. Reaction of *spiro*-(Cyclopentane-1,2′-*pseudo*-indoxyl) with Methyllithium.—A solution of methyllithium was prepared by reacting 140 mg. of finely cut lithium with 0.7 ml. of methyl iodide in 10 ml. of anhydrous ether. When the reaction was complete 950 mg. of *spiro*-(cyclopentane-1,2′-*pseudo*-indoxyl) in 10 ml. of ether and 5 ml. of tetrahydrofuran was added. There was a moderate reaction with formation of a bright red oily layer at the bottom of the mixture. The solution was refluxed for 2 hours and allowed to stand overnight. It was then decomposed with water and the aqueous layer extracted with ether. The combined ether layers were extracted with 2 *N* hydrochloric acid; the acid extracts were made alkaline and extracted with ether, and the ether solution dried and evaporated. The residue which exhibited an odor reminiscent of camphor was taken up in 0.1 *N* hydrochloric acid and treated with aqueous picric acid. The picrate precipitated immediately in crystalline condition (approximately 100 mg.) and was washed with 1 ml. of methanol and recrystallized from acetone. A lemon yellow, crystalline powder was obtained, m.p. 172–173°; transformation into small prisms at 135°, some sintering at 161°, finally clear yellow melt. A mixed melting point with authentic 11-methyltetrahydrocarbazolenine picrate (m.p. 173°) showed no depression (171–173°). The yield from the reaction was about 10% of the theoretical; approximately 90% of unreacted starting material was recovered.

Anal. Calcd. for $C_{18}H_{15}N \cdot C_6H_3O_7N_3$: C, 55.07; H, 4.38. Found: C, 54.78; H, 4.59.

B. Fischer Synthesis from 2-Methylcyclohexanol.—A small amount of 11-methyltetrahydrocarbazolenine[9,10] in ether was treated with an ether solution of dry hydrogen chloride. The precipitate became crystalline on rubbing. The crude hydrochloride was subjected to sublimation *in vacuo* and the sublimate recrystallized from ethanol–ether. There were obtained clusters of rectangular prisms, m.p. 166°, clear colorless melt.

(19) The extraordinary mobility of the chlorine in this position was demonstrated by Leuchs, Wulkow and Gerland, *Ber.*, **65**, 1586 (1932); Leuchs and Schlötzer, *ibid.*, **67**, 1572 (1934).

(20) Leuchs worked exclusively with 3,3-dialkyl-1-acyl-2-chloroindolines; compounds of this type have not been observed to reduce silver salt solutions; *cf.* Schlötzer, Dissertation, University of Berlin, 1935.

(21) Plancher, *Gazz. chim. ital.*, **28**, II, 374 (1898); *Atti R. Accad. Lincei*, [5], **9**, 115 (1900).

(22) Boyd-Barret, *J. Chem. Soc.*, 321 (1932).

(23) Plancher and Bonaviva, *Gazz. chim. ital.*, **32**, II, 414 (1902).

(24) Garry, *Ann. chim.*, [11] **17**, 5–99 (1942).

(25) *Cf.* Pausacker, *J. Chem. Soc.*, 119 (1950).

(26) All the melting points are corrected. The analyses were carried out by Mr. S. M. Nagy and his associates, Microchemical Laboratory, Massachusetts Institute of Technology.

Anal. Calcd. for $C_{13}H_{15}N\cdot HCl$: C, 70.41; H, 7.27. Found: C, 70.22[27]; H, 7.49.

Picrate.—A small amount of the above hydrochloride in aqueous solution was treated with aqueous picric acid. The crystalline precipitate was collected and recrystallized from acetone. Clusters of small lemon yellow prisms were obtained, m.p. 172–173°, crystalline transformation to short prisms at 135–145°.

spiro-(**Cyclopentane-1,3′-*pseudo*-2-methylindole**) (**XXIII**) **A. Reaction of** *spiro*-(**Cyclopentane-1,2′-*pseudo*-indoxyl**) **with Methylmagnesium Iodide.**—A solution of 800 mg. of *spiro*-(cyclopentane-1,2′-*pseudo*-indoxyl) in 10 ml. of tetrahydrofuran was slowly added to an ether solution of methylmagnesium iodide prepared from 700 mg. of magnesium turnings and 4 g. of methyl iodide. The resulting dark red solution was refluxed for an hour and then decomposed with ice and 2 *N* hydrochloric acid. The aqueous layer was separated, made basic, and extracted with ether. Evaporation of the ether solution, following drying over anhydrous sodium sulfate, yielded approximately 50 mg. of an oil having a characteristic odor reminiscent of certain terpenoid ketones.

Picrate.—The product was taken up in 0.1 *N* hydrochloric acid and aqueous picric acid was added. The resultant precipitate was immediately crystalline. On drying 170 mg. of picrate was obtained. The material was recrystallized first from methanol and then from acetone, forming orange-yellow prisms, m.p. 186–190°, sintering 178°, orange-yellow melt.

Anal. Calcd. for $C_{13}H_{15}N\cdot C_6H_3O_7N_3$: C, 55.07; H, 4.38. Found: C, 55.08; H, 4.72.

A mixed melting point of this picrate with a sample of the picrate of 11-methyltetrahydrocarbazolenine (m.p. 172–173°) showed definite depression (160–168°).

Hydrochloride.—The picrate was taken up in ether and treated with alkali to liberate the free base. The ethereal solution was dried and evaporated. Treatment of the residue with ethereal hydrogen chloride yielded an oily hydrochloride which became crystalline on rubbing and standing. On recrystallization from ethanol–ether (1:3) the substance was obtained as rose-colored cubes, colorless when powdered, m.p. 180–182°, transformation to small lozenges and sublimation at 130°, sintering 171°.

Anal. Calcd. for $C_{13}H_{15}N.HCl$: C, 70.41; H, 7.27. Found: C, 70.12; H, 7.14 (burned with copper oxide).

B. Reaction of 11-Hydroxytetrahydrocarbazolenine with Methylmagnesium Iodide.—One gram of 11-hydroxytetrahydrocarbazolenine (I) dissolved in 20 ml. of tetrahydrofuran was added to a Grignard solution prepared from 1 g. of magnesium turnings and 2 ml. of methyl iodide in 20 ml. of anhydrous ether. A vigorous reaction ensued, accompanied by evolution of heat. No significant color was observed. The reaction mixture was refluxed for an hour, during which time a colorless crystalline substance was deposited. The reaction mixture was decomposed with ice (no acid) and the ether phase dried over anhydrous sodium sulfate and evaporated. The residue was approximately 0.75 g. of a slightly yellow oil.

i. **Colorless Hydrochloride.**—The crude oily base was taken up in ether and treated with dry hydrogen chloride. The hydrochloride first formed an oil which became crystalline on standing. The ether washings from the hydrochloride contained very little spiran (II) which betrayed itself by the strong fluorescence after neutralization of the acidic ether extracts. Recrystallization from alcohol–ether (1:3), when carried out slowly and at room temperature, furnished small colorless prisms, m.p. 179–184°, 130–140° some sintering and subsequent resolidification, 145° transformation into secondary crystals, 168° sintering.

(27) All hydrochlorides of this type mentioned in this experimental part were burned with copper oxide. Without this precaution carbon was often found too low by as much as 1%.

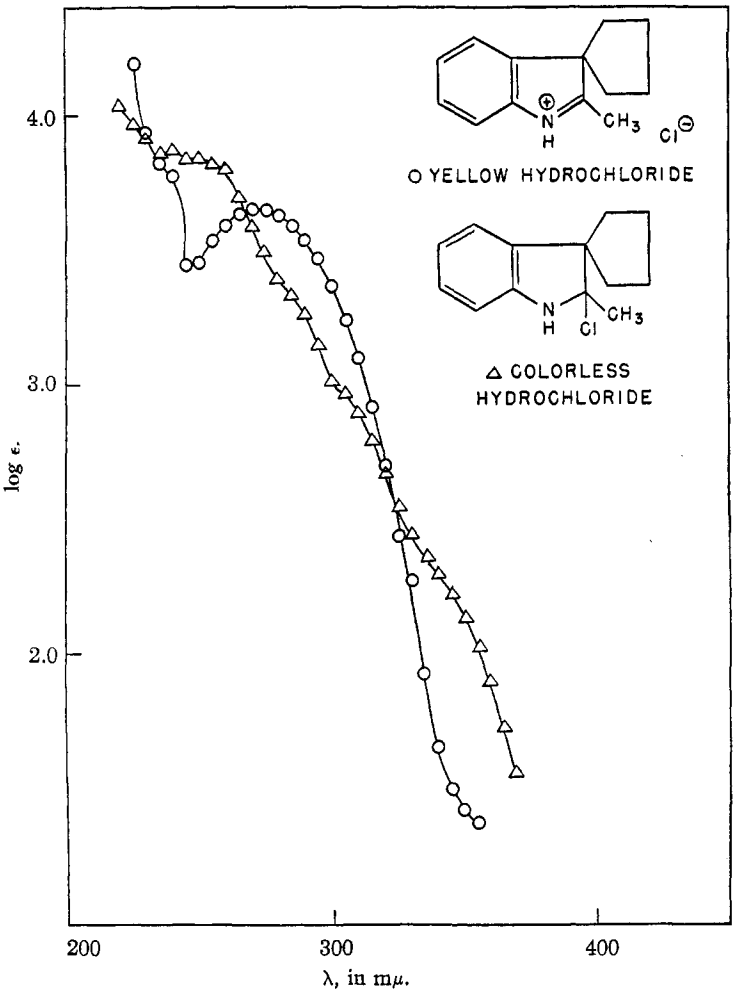


Fig. 4.—Ultraviolet spectra of the two isomeric *spiro*-(cyclopentane-1,3′-*pseudo*-2′-methylindole) hydrochlorides.

Anal. Calcd. for $C_{13}H_{15}N\cdot HCl$: C, 70.41; H, 7.27. Found: C, 70.62; H, 7.32.

The addition of a drop of dilute silver nitrate solution, made slightly acidic with nitric acid, to an aqueous solution of the colorless hydrochloride produced a precipitate that increased slightly after shaking and standing for a few seconds and that turned black rapidly.

ii. **Yellow Hydrochloride.**—The ethanol–ether mother liquors of the colorless hydrochloride after addition of more ether deposited slowly growing, slightly yellow transparent prisms, m.p. 178–184°, 150–160° transformation into smaller aggregates, 175° sintering, finally clear yellow melt.

Anal. Calcd. for $C_{13}H_{15}N\cdot HCl$: C, 70.41; H, 7.27. Found: C, 70.56; H, 7.32.

The silver nitrate test, carried out with the yellow hydrochloride, produced a precipitate of silver chloride immediately without any discoloration on standing.

Picrate.—A small amount of each hydrochloride was converted to the picrate by treatment with 2 *N* potassium hydroxide, extraction with ether and, after drying over anhydrous sodium sulfate, addition of ethereal picric acid. On recrystallization from methanol one obtained identical picrates, in the form of yellow rods, m.p. 188–192°.

C. Fischer Synthesis from Methyl Cyclopentyl Ketone. Methyl Cyclopentyl Ketone by Inverse Grignard Addition.—A Grignard solution was prepared from 10 g. of cyclopentyl bromide and 1.6 g. of magnesium turnings in 25 ml. of anhydrous ether. This solution was added with rapid stirring to 5.25 g. of acetyl chloride in 37 ml. of anhydrous ether as fast as the boiling ether would permit. The mixture was vigorously stirred 10 min. more, then cooled and decomposed with ice and dilute hydrochloric acid. After washing with dilute hydrochloric acid, alkali, and distilled water, the

ether layer was dried over anhydrous sodium sulfate and distilled. The yield of methyl cyclopentyl ketone (b.p. 160–163°) was 2.3 g. (30% of the theoretical).

Methyl Cyclopentyl Ketone from Dicyclopentylcadmium and Acetyl Chloride.—A Grignard solution was prepared from 7.5 g. (0.05 mole) of cyclopentyl bromide and 1.2 g. (0.05 mole) of magnesium turnings in 25 ml. of anhydrous ether. The Grignard reagent was formed with great ease. When the reaction was complete and had been refluxed for 20 minutes, the solution was chilled in a Dry Ice–acetone-bath and 4.6 g. (0.025 mole) of anhydrous cadmium chloride were slowly added. The reaction mixture was vigorously agitated throughout the addition and care was taken to keep the temperature low. When the addition was complete, the suspension was allowed to stand 20 minutes at the Dry Ice-bath temperature. A solution of 3.5 ml. of acetyl chloride in 10 ml. of anhydrous ether was then slowly added while cooling was maintained. After 5 minutes the cooling bath was removed and the reaction mixture was allowed to warm up to room temperature. The mixture was finally refluxed for 20 minutes. After standing overnight it was decomposed with ice and dilute sulfuric acid. The ether layer was washed with dilute alkali, which removed part of the yellow color, and with distilled water. The light amber-colored ether solution was dried over sodium sulfate and distilled. The colorless distillate, boiling at 160–163°, amounted to 1.8 g. (30% of the theoretical).

spiro-(**Cyclopentane-1,3′-*pseudo*-2-methylindole**).—To a solution of 11.2 g. (0.09 moles) of methyl cyclopentyl ketone in 68 ml. of glacial acetic acid was added 9.6 ml. (0.09 moles) of phenylhydrazine. The solution was refluxed for an hour, then cooled and made basic with potassium hydroxide. The basic solution was thoroughly extracted with ether, the ether solution was dried over sodium sulfate followed by potassium hydroxide pellets. Evaporation of the ether solution left 1.6 g. of a dark red oil, which was distilled *in vacuo* in a small sausage flask. The first fraction was a yellow oil, distilling at 100° (bath) and 35 mm. The second fraction (120–145°) at 2 mm. was an orange oil which partly crystallized in colorless plates, m.p. 125–128°. This crystalline material was identified as N-acetylphenylhydrazine. (*Anal.* Calcd. for $C_8H_{10}ON_2$: C, 63.98; H, 6.71; N, 18.66. Found: C, 64.00; H, 6.46; N, 18.87.) The extraction of the ether mother liquor with 0.1 *N* hydrochloric acid and addition of picric acid yielded a crystalline picrate. Recrystallization from acetone furnished yellow needles, m.p. 188–192°, orange yellow melt.

Anal. Calcd. for $C_{13}H_{15}N\cdot C_6H_3O_7N_3$: C, 55.07; H, 4.38. Found: C, 54.88; H, 4.18.

Hydrochloride.—A small amount of the picrate was converted into the hydrochloride in the usual fashion. The hydrochloride, after recrystallization from ethyl alcohol ether, melted at 180–184°.

Anal. Calcd. for $C_{13}H_{15}N\cdot HCl$: C, 70.41; H, 7.27. Found: C, 70.50; H, 7.38.

spiro-(**Cyclopentane-1,3′-*pseudo*-2-ethylindole**) (**XXIV**).—To an ether solution of excess ethylmagnesium iodide was added 630 mg. of *spiro*-(cyclopentane-1,2′-*pseudo*-indoxyl) (II) in 6 ml. of tetrahydrofuran. An orange precipitate formed immediately. The solution was refluxed for 45 minutes and, since the precipitate had not dissolved, 40 ml. of tetrahydrofuran was added and refluxing was continued for another hour. The reaction mixture was then cooled and decomposed with water and dilute alkali. The ether layer was separated, dried over sodium sulfate and evaporated. The syrupy residue was triturated with 0.1 *N* hydrochloric acid and the resulting solution treated with aqueous picric acid. The picrate was recrystallized from methanol (yield 270 mg.). Two more recrystallizations from methanol yielded yellow needles with a greenish tinge, m.p. 142–144°.

Anal. Calcd. for $C_{14}H_{17}N\cdot C_6H_3O_7N_3$: C, 56.07; H, 4.71. Found: C, 55.79; H, 4.93.

A mixed melting point with the picrate of 11-ethyltetrahydrocarbazolenine (m.p. 148–150°) showed a large depression (123–130°).

Hydrochloride.—The picrate in ether suspension was treated with alkali to liberate the free base. After drying of the ether phase over sodium sulfate dry hydrogen chloride produced the hydrochloride. This hydrochloride crystallized from water in colorless prisms, m.p. 181–183°, sublimation in rods starting at 130°, darkening from 170°. A mixed melting point with 11-ethyltetrahydrocarbazolenine hydrochloride (m.p. 176–181°) showed a depression (169–181°).

11-Ethyltetrahydrocarbazolenine Hydrochloride.—The 2-ethylcyclohexanone used in the Fischer indolenine synthesis[9,10] was prepared by condensing 3 moles of cyclohexanone with 1 mole of acetaldehyde,[28,29] dehydration of the resulting ketole with iodine,[30] and hydrogenation of the 2-ethylidenecyclohexanone.[31] The hydrochloride of the indolenine was prepared from ethereal solution using dry hydrogen chloride. The salt formed hexagonal prisms from ethanol–ether (1:2), m.p. 176–181°, transformation to smaller aggregates 120–150°, sintering 168°, clear melt.

Anal. Calcd. for $C_{14}H_{17}N\cdot HCl$: C, 71.27; H, 7.66. Found: C, 71.06; H, 7.93.

Picrate.—The picrate, prepared in the usual manner, formed golden yellow prisms on recrystallization from methanol, m.p. 148–150°.

Acknowledgment.—We are indebted to Research Corporation, New York, for a grant-in-aid in support of this investigation.

(28) Vavon and Mitchovitch, *Bull. soc. chim.*, [4] **45**, 964 (1929).
(29) Grignard and Dubien, *Ann. chim.*, [10] **1**, 288 (1924).
(30) Hibbert, THIS JOURNAL, **37**, 1748 (1915).
(31) Garland and Reid, *ibid.*, **47**, 2333 (1925).

CAMBRIDGE 38, MASSACHUSETTS RECEIVED JUNE 22, 1950

[CONTRIBUTION FROM THE CHEMISTRY DEPARTMENT, NEW MEXICO HIGHLANDS UNIVERSITY]

The Ultraviolet Absorption Spectra of Acrylic Acids and Esters

BY HERBERT E. UNGNADE AND ISHMAEL ORTEGA

The literature reports a number of absorption spectra for various acrylic acids but the differences among authors in the location and extinction values of the maxima even for the same type of acid exceed the experimental error of the method. As an example, Dimroth[1] summarizing the data for crotonic acid and other acids of the type RCH=CH—COOH (I) gives λ_{max}(EtOH) 204–205 mμ, log ε 4.06–4.14. Later precise measurements by Van der Hulst[2] and by Lauer, Gensler and Miller[3] locate the maximum for the acids (I) at 210 mμ (log ε 4.5). Rusoff, *et al.*,[4] report an even higher wave length for the maximum (213 mμ) but a lower extinction value (log ε 4.2). There is little doubt that all investigators were dealing with the stable *trans*-isomers and with reasonably pure compounds.

According to Caliezi and Schinz[5] the absorption curves of α,β-unsaturated acids show a maximum at about 230 mμ. Other investigators fail to find a maximum in the observed region and report only general absorption, *e.g.*, Jones, Shen and Whiting[6] who measured the acids $R_2C(OH)C(COOH)=$

(1) Dimroth, *Angew. Chem.*, **52**, 551 (1939).
(2) Van der Hulst, *Rec. trav. chim.*, **54**, 639 (1935).
(3) Lauer, Gensler and Miller, THIS JOURNAL, **63**, 1153 (1941).
(4) Rusoff, Platt, Klevens and Burr, *ibid.*, **67**, 678 (1945).
(5) Caliezi and Schinz, *Helv. Chim. Acta*, **32**, 2557 (1949).
(6) Jones, Shen and Whiting, *J. Chem. Soc.*, 230 (1950).