(8 liters). The 5% and 15% ethanol effluents were evaporated to sirups under reduced pressure and further dried by distillation with methanol under reduced pressure; yields 5 g. and 6 g., respectively.

β-Isomaltose Octaacetate.—The 5 g. of amorphous material from the 5% ethanol effluent was acetylated with 2 g. of sodium acetate and 40 ml. of acetic anhydride at a temperature just below the boiling point of the mixture. The excess acetic anhydride was hydrolyzed by stirring with 200 g. of ice and water; yield 9 g. of acetylated sirup. This material was dissolved in 90 ml. of benzene and chromatographed on two 275 × 80 mm. (i.d.) columns of Magnesol[14]–Celite[15] (5:1 by wt.) and each was developed with 3000 ml. of benzene–*t*-butyl alcohol (50:1 by vol.). Four zones were located by streaking the extruded columns with permanganate indicator (1% $KMnO_4$ in 10% NaOH). The sectioned zones were eluted with acetone and the acetone was removed by evaporation under reduced pressure. The material from the three top zones failed to crystallize; that in the zone near the bottom crystallized from ethanol; yield 360 mg., m.p. 144–145° unchanged on admixture with authentic β-isomaltose octaacetate, $[\alpha]^{22}\text{D}$ +96° (*c* 2.9, chloroform). These values agree with those (143–144°, +97°) accepted[2] for β-isomaltose octaacetate.

Panitol Dodecaacetate.—The material (6 g.) from the 15% ethanol effluent from the carbon column was acetylated in the manner just described. The resulting acetylated material was chromatographed on Magnesol–Celite as described above except that 3000 ml. of benzene–*t*-butyl alcohol (35:1 by vol.) was used as the developing agent. Four zones appeared on the column. The zone material was removed from the sectioned column by elution with acetone. After removal of the acetone the zone failed to crystallize. The benzene–*t*-butyl alcohol effluent was evaporated to dryness to give β-maltose octaacetate; yield 0.5 g., m.p. 155–156°, $[\alpha]^{23}\text{D}$ +63° (accepted values: 159–160°, +63°). The material (0.9 g., from the second zone from the top of the column was dissolved in 10 ml. of 0.05 *N* $NaOCH_3$ in methanol and allowed to remain at 5° overnight. It was then diluted with 50 ml. of water and passed successively through ion exchange columns (150 × 20 mm. i.d.) of Amberlite 120[17] and Duolite A-4[13]. The solution and washings were evaporated to 50 ml. under reduced pressure. The sugar was then hydrogenated at 1800 p.s.i. and 80° for 3 hr. in the presence of 2 g. of Raney nickel catalyst. After filtration and removal of the solvent by evaporation under reduced pressure, the resultant amorphous material was again acetylated with sodium acetate (0.3 g.) and acetic anhydride (7 ml.) as described above. The resulting sirup crystallized from ethanol; yield 35 mg., m.p. 138–144°. The mother liquor was evaporated to a sirup and redissolved in 30 ml. of benzene. This solution was placed on a column (275 × 80 mm. i.d.) of Silene[18]–Celite[15] (5:1 by wt.) and developed with 4 liters of benzene–*t*-butyl alcohol (75:1 by vol.). Three zones appeared on the column which were sectioned and eluted with acetone. Crystalline material was obtained from the zone near the column top; yield 90 mg., m.p. 140–145°. The combined portions of crystalline material (125 mg.) were further purified by three recrystallizations from ethanol; yield 70 mg. (0.1%), m.p. 147–148° unchanged on admixture with authentic panitol dodecaacetate (m.p. 148.5–150°, $[\alpha]^{25}\text{D}$ +120° in chloroform[7]), $[\alpha]^{25}\text{D}$ +118° (*c* 2.6, chloroform). X-Ray powder diffraction data: 8.51[19] –70,[20] 6.96–20, 5.73–5, 4.66–100, 4.08–20, 3.36–40, 3.17–5, 2.97–10, 2.67–10, 2.35–5. The X-ray diagram was identical with that of an authentic sample of panitol dodecaacetate.

Columbus 10, Ohio Received June 7, 1951

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[16] A product of Westvaco Chlorine Products Corp., South Charleston, West Virginia.

[17] A product of Rohm and Haas Co., Philadelphia, Pennsylvania.

[18] A product of the Columbia Chemical Co., Barberton, Ohio.

[19] Interplanar spacing, Å.; CuKα radiation.

[20] Relative intensity as percentage strongest line; estimated visually.

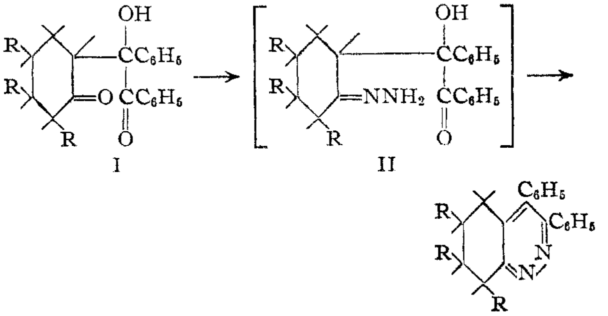
[Communication No. 1403 from the Kodak Research Laboratories]

Some 3,4-Diphenylcinnolines and Related Compounds

By C. F. H. Allen and J. A. VanAllan

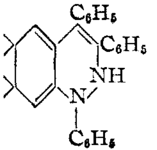
2-(Hydroxydesyl)-cyclohexanones have been converted into 5,6,7,8-tetrahydrocinnolines by treatment with hydrazine. These are the first reduced cinnolines, other than 1,2-dihydro derivatives, to be described. A variety of substances result on dehydrogenation in the presence of a palladium catalyst. The principal product is an indole, but a true cinnoline is also formed; the reaction is not a useful source of cinnolines. The cinnolines described in this paper form salts with one equivalent of an alkyl halide. Improved procedures are given for the preparation of benzil monophenylhydrazone and 3,4-diphenylcinnoline.

When 2-(hydroxydesyl)-4(or 5, or 6)-methylcyclohexanones (I)[1] are treated with hydrazine, water is eliminated as with other 1,4-diketones and reduced cinnolines (1,2-diazanaphthalenes) (III) are formed.

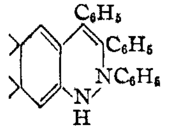


III

The intermediate hydrazone (II) cannot be isolated unless phenylhydrazine or 2,4-dinitrophenylhydrazine is used. These two derivatives have been previously described.[2] While the monophenylhydrazone is readily cyclized, all attempts to cyclize the dinitro derivative failed. No attempt has been made to determine which of the two most likely structures is correct for the tetrahydrocinnoline (IVa, b) derived from phenylhydrazine.



IVa



IVb

The tetrahydrocinnolines (III) do not evolve methane when treated with methylmagnesium iodide; hence, it is unlikely that any hydrogen is attached to nitrogen. Since these substances do

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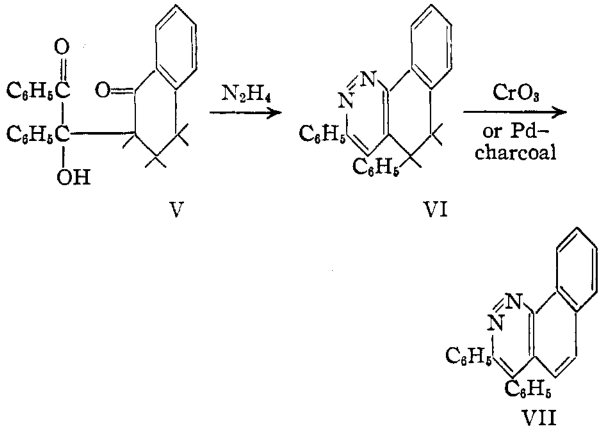
[1] C. F. H. Allen and J. A. VanAllan, *J. Org. Chem.*, 16, 716 (1951).

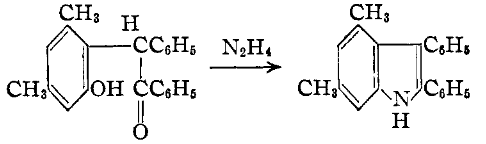
[2] C. F. H. Allen, *Can. J. Research*, 4, 264 (1931).

not reduce permanganate nor add bromine, it seems reasonable to conclude that the four hydrogen atoms are on the all-carbon ring,[2] as would be inferred from the method of preparation.

The diketone (V) formed from α-tetralone,[1] on similar treatment, gives a dihydrodiazaphenanthrene (VI) which is easily dehydrogenated to give the aromatic diazaphenanthrene (benzocinnoline) (VII). The phenolic ketone (VIII), obtainable from 3,5-dimethyl-2-cyclohexenone and benzil,[1] gives 4,6-dimethyl-2,3-diphenylindole (IX) when treated with hydrazine.



V VI VII

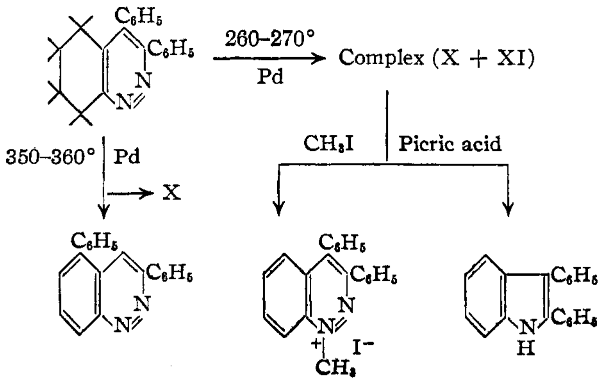


VIII IX

When the tetrahydrocinnolines (III) are dehydrogenated, using palladium on charcoal, ammonia is evolved and a mixture of substances results; the composition of this mixture depends upon the reaction conditions, but the major portion of the reaction mixture is always a diaryl indole. If the dehydrogenation is carried out at 260–270°, a molecular complex of the cinnoline and a diaryl indole is isolated, whereas if the dehydrogenation is carried out at 350–360°, a compound isomeric with 3,4-diphenylcinnoline is obtained, the structure of which is unknown.

The composition of the complex, obtained by dehydrogenating 3,4-diphenyltetrahydrocinnoline at 260–270° was established by treating it with methyl iodide in nitrobenzene. The resulting methiodide is identical with 3,4-diphenylcinnoline methiodide (XI). The other component of this complex was identified by treating the complex with picric acid; this treatment gave the known picrate[3] of 2,3-diphenylindole.

Further evidence was obtained for the composition of this complex from the ultraviolet absorption curves (Fig. 1). In solution, the molecular bonding is broken and the resulting curve is a composite of 3,4-diphenylcinnoline and 2,3-diphenylindole, the maxima matching exactly. Finally, this complex was prepared by mixing equal weights of the components together.



XII XI X

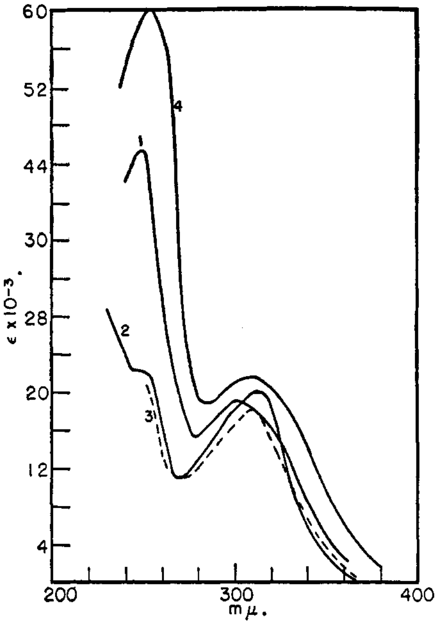


Fig. 1.—Ultraviolet absorption spectra in methanol of (1) complex of 3,4-diphenylcinnoline and 2,3-diphenylindole; (2) 2,3-diphenyl-5-methylindole; (3) 2,3-diphenylindole; (4) complex of 3,4-diphenyl-7-methylcinnoline and 2,3-diphenyl-6-methylindole.

If the dehydrogenation of 3,4-diphenyltetrahydrocinnoline is carried out at 350–360°, 2,3-diphenylindole and another substance (XII) are obtained. The new substance, which is isomeric with 3,4-diphenylcinnoline, differs from 3,4-diphenylcinnoline in color, ultraviolet absorption and picrate formation. Analogous substances were also obtained from 6- and 7-methyl-5,6,7,8-tetrahydrocinnolines. The ultraviolet absorption curves (Fig. 2) of these compounds are almost identical, which identifies them as belonging to an homologous series. Moreover, their curves are quite similar to the known cinnolines, but the maxima are shifted about 160 Å. toward the longer wave lengths. For this reason and from the fact that the elementary analyses are in such good agreement in all three cases with that of the completely aromatic cinnoline, these compounds are regarded as cinnolines. Because of the frequent 1,3-shift of phenyl groups in highly arylated com-

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[3] A. Bischler and P. Fireman, *Ber.*, **26**, 1336 (1893).

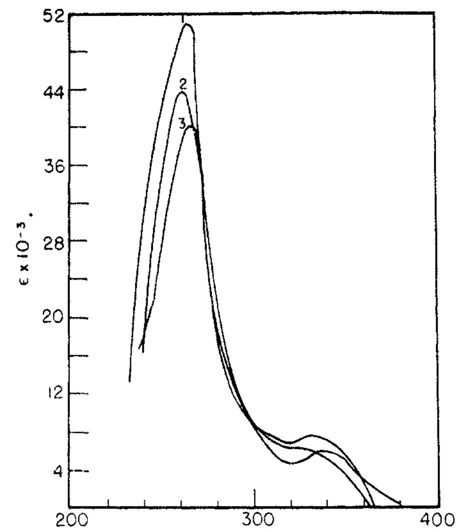
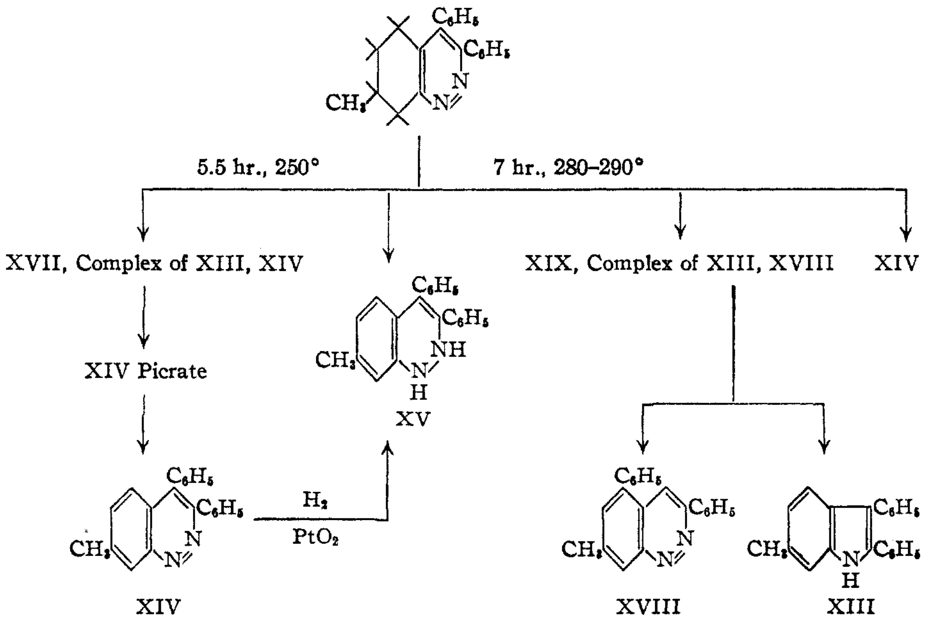


Fig. 2.—Ultraviolet absorption spectra in methanol of (1) 3,5-diphenyl-7-methylcinnoline; (2) 3,5-diphenylcinnoline; and (3) 3,5-diphenyl-6-methylcinnoline.

pounds[4] it is tentatively suggested that the substances in question may be 3,5-diarylcinnolines.

Upon dehydrogenating 7-methyl-3,4-diphenyl-5,6,7,8-tetrahydrocinnoline, there were obtained: 7-methyl-3,4-diphenylcinnoline (XIV); 7-methyl-3,4-diphenyl-1,2-dihydrocinnoline (XV); 6-methyl-2,3-diphenylindole (XIII) identified by m.p. and picrate; a 1:1 molecular complex (XVII) of XIV and XIII; an isomer of 7-methyl-3,4-diphenylcinnoline (XVIII); and its complex with 6-methyl-2,3-diphenylindole (XIX).



Upon dehydrogenation at 360–370°, 8-methyl-3,4-diphenyl-5,6,7,8-tetrahydrocinnoline (XX) gave the known 7-methyl-2,3-diphenylindole (XVI)[3,5,6] and a small amount of 8-methyl-3,4-diphenylcinnoline (XXI). The 6-methyl isomer, similarly treated, gave the known 5-methyl-2,3-diphenylindole[3] and an isomeric cinnoline, analogous to XII.

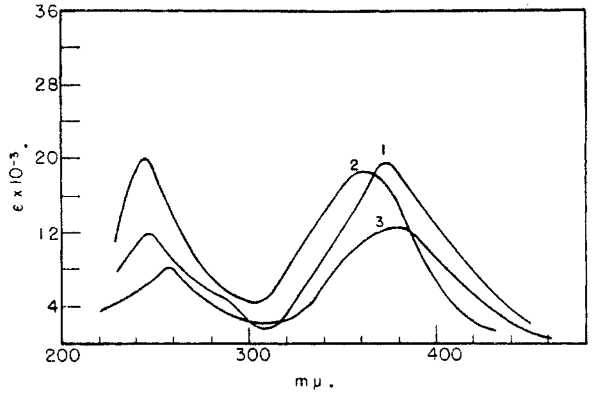
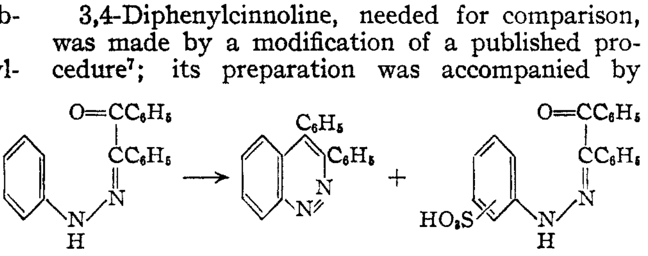


Fig. 3.—Ultraviolet absorption spectra in methanol of (1) phenylglyoxal-ω-phenylhydrazone; (2) benzil monophenylhydrazone; and (3) sodium phenylglyoxal-ω-phenylhydrazone-*x*-sulfonate.

3,4-Diphenylcinnoline, needed for comparison, was made by a modification of a published procedure[7]; its preparation was accompanied by



considerable sulfonation. In an unsuccessful attempt to prepare 4-phenylcinnoline by the same type of reaction (*i.e.*, action of sulfuric acid on the monophenylhydrazone of phenylglyoxal), only an open-chain sulfonic acid was obtained. The absorption curve of the sulfonated material (Fig. 3) was practically the same as that of the phenylhydrazone, indicating there had been no cyclization to a cinnoline.

3,4-Diphenylcinnoline was easily converted to a dihydrocinnoline by reduction of an alcoholic solution in the presence of Adams platinum catalyst at room temperature. The new substance, which does not form a picrate, is easily dehydrogenated, catalytically or by chromium trioxide, to the original cinnoline; such behavior is said to be characteristic of 1,2-dihydrocinnolines.[8] The 7-

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(4) C. F. H. Allen, *Chem. Revs.*, **37**, 233, 263 (1945).

(5) F. R. Japp and T. S. Murray, *J. Chem. Soc.*, **65**, 891 (1894).

(6) F. R. Japp and T. S. Murray, *Ber.*, **26**, 2640 (1893).

(7) B. P. Moore, *Nature*, **163**, 919 (1949).

(8) P. W. Neber, G. Knoller, K. Herbst and A. Trissler, *Ann.*, **471**, 113 (1929).

methyl homolog showed a similar behavior. The ultraviolet absorption curves of the 3,4-diphenylcinnolines are shown in Fig. 4.

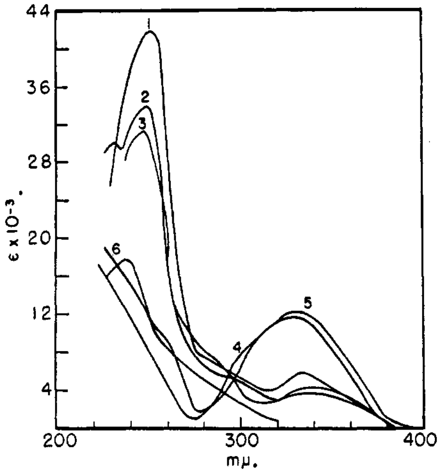
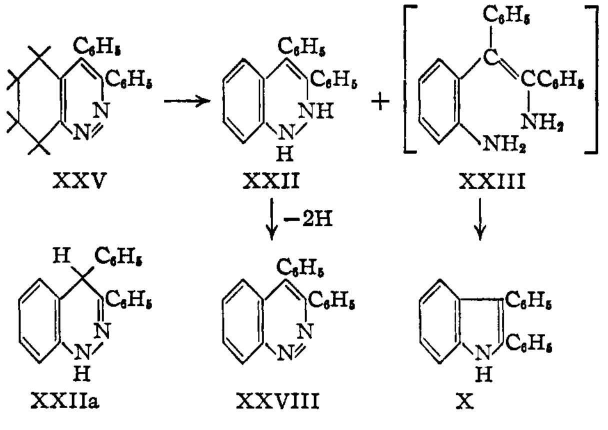
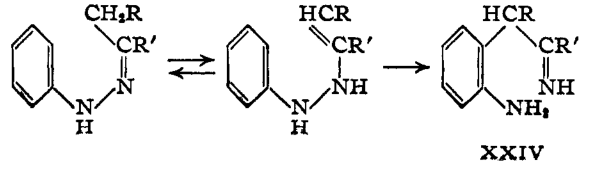


Fig. 4.—Ultraviolet absorption spectra in methanol of (1) 3,4-diphenyl-7-methylcinnoline; (2) 3,4-diphenylcinnoline; (3) 3,4-diphenyl-8-methylcinnoline; (4) 1,4-dihydro-3,4-diphenyl-7-methylcinnoline; (5) 1,4-dihydro-3,4-diphenylcinnoline; and (6) 3,4-diphenyl-5,6,7,8-tetrahydrocinnoline.

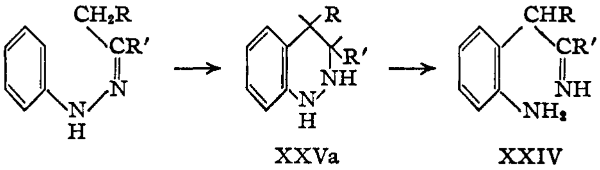
Surprisingly, both dihydro derivatives showed but one active hydrogen when treated quantitatively with methylmagnesium iodide. This indicates there can be only one hydrogen on a nitrogen atom, and implies that the substances are not correctly represented as 1,2-addition products (XXII). The alternative is a dihydro derivative with the hydrogen in the 1- and 4-positions (XXIIa). It could be formed by a direct 1,4-addition or, more probably, by a 1,2-addition followed by a 1,3-shift of hydrogen.



The hypothetical substance (XXIII) bears a striking superficial resemblance to one of the assumed intermediates (XXIV) postulated in the modern mechanism advanced to explain the Fischer indole synthesis.



If a slightly different interpretation should be considered, in which the ring is closed as a preliminary step, the intermediate would be a reduced cinnoline (XXVa).



This interpretation cannot be correct, because the tetrahydrocinnolines described in this paper are not transformed to indoles under the conditions used in the Fischer indole synthesis.

The tetrahydrocinnolines form salts with but one equivalent of methyl iodide; the methiodides were converted to perchlorates in some cases. Bis-salts are obtained with decamethylene bromide. The indoles do not form methiodides but give picrates easily.

Ultraviolet absorption spectra are given in Figs. 1–5; since little is known of the absorption of cinnolines, the curve for 6-bromo-4-phenylcinnoline, which was at hand, is included. Methanol solutions were used, unless otherwise indicated. It may be noted that the structural formulas for the 3,4-diphenyl-5,6-dihydro-1,2-diazaphenanthrene (VI) and 3,4,6-triphenylpyridazine bear a formal similarity as regards structure. This similarity is reflected in the ultraviolet absorption curves (Fig. 5).

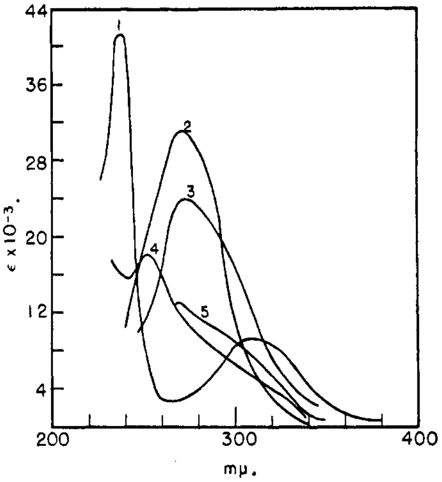


Fig. 5.—Ultraviolet absorption spectra in methanol of (1) 6-bromo-4-phenylcinnoline; (2) 3,4-diphenyl-5,6-dihydro-1,2-diazaphenanthrene; (3) 3,4,6-triphenylpyridazine; (4) 3,4-diphenyl-1,7-dimethyl-5,6,7,8-tetrahydrocinnolinium iodide; and (5) 1,3,4-triphenyl-1,2,3,4-tetrahydrocinnoline (in dioxane).

Experimental

5,6,7,8-Tetrahydrocinnolines (III).—These were all obtained in 80–90% yields, by this general procedure. A mixture of 77 g. of 2-(hydroxydesyl)-cyclohexanone,[1] 200 ml. of toluene and 42 ml. of 100% hydrazine hydrate was refluxed under an ester column[9] as long as water was collected. The residual solution was then transferred to a beaker and an equal volume of ligroin (b.p. 90–120°) added. After stand-

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[9] H. T. Clarke and E. J. Rahrs, *Ind. Eng. Chem.*, **18**, 1092 (1926).

TABLE I

PROPERTIES OF 3,4-DIPHENYL-5,6,7,8-TETRAHYDROCINNOLINES[a]

	Substituent	M.p., °C.	Empirical formula	Analyses, % Calcd. C	Calcd. H	Found C	Found H
XXV	Unsubstituted III, R = H	173[b,c]	$C_{20}H_{18}N_2$	83.9	6.3	83.9	6.4
XXVI	6-Methyl	192	$C_{21}H_{20}N_2$	84.0	6.7	83.6	6.9
	6-Isopropyl	146	$C_{23}H_{24}N_2$	85.2	6.2	85.4	5.9
	6-*s*-Butyl	110-111	$C_{24}H_{25}N_2$	83.4	8.0	83.8	7.9
XXVII	7-Methyl	170	$C_{21}H_{20}N_2$	84.0	6.7	84.2	6.8
XX	8-Methyl	147	$C_{21}H_{20}N_2$	84.0	6.7	84.2	6.6
IV	N-Phenyl	250-251	$C_{26}H_{22}N_2$	86.2	6.1	86.1	6.5
	Picrates[d] of XXV	165	$C_{26}N_{20}N_5O_7$	60.6	4.1	60.8	4.3
	XXVI	167	$C_{27}H_{23}N_5O_7$	61.2	4.4	61.2	4.7
	XXVII	174	$C_{27}H_{23}N_5O_7$	61.2	4.4	61.5	4.5
	XX	182	$C_{27}H_{23}N_5O_7$	61.2	4.4	61.6	4.6

[a] All colorless and recrystallized from toluene–ligroin. [b] B.p., 290° (1 mm.). [c] Mol. wt.: calcd. 286; found 261 (ethanol). [d] Yellow needles, from alcohol.

TABLE II

PROPERTIES OF THE 2,3-DIPHENYLINDOLES AND THEIR PICRATES

No.	Substituent	M.p., °C.	Empirical formula	Analyses, % Calcd. C	Calcd. H	Calcd. N	Found C	Found H	Found N
X	Unsubstituted	123[a]	$C_{20}H_{15}N$	89.2	5.6		89.0	5.8	
	5-Methyl[5]	155	$C_{21}H_{17}N$						
XIII	6-Methyl	104	$C_{21}H_{17}N$	88.9	6.0	5.0	88.8	6.1	4.8
XVI	7-Methyl[5]	128	$C_{21}H_{17}N$						
IX	4,6-Dimethyl	193	$C_{22}H_{19}N$	88.7	6.1		88.4	6.1	
	Picrates of XIII	169	$C_{27}H_{20}N_4O_7$	63.3	3.9	11.0	63.5	4.1	10.9
	XVI	175	$C_{27}H_{20}N_4O_7$	63.3	3.9	11.0	63.3	4.4	11.0
	X	155	$C_{26}H_{18}N_4O_7$	62.4	3.6	11.2	62.9	3.9	11.8

[a] Active hydrogen, found: 0.9, 0.9.

TABLE III

YELLOW COMPLEXES OF CINNOLINES AND INDOLES

No.	Components	M.p., °C.	Empirical formula	Analyses, % Calcd. C	Calcd. H	Calcd. N	Found C	Found H	Found N
	X, XXVIII	128-129	$C_{40}H_{29}N_3$	87.0	5.3	7.6	87.2	5.2	7.5
XVII	XIII, XIV	151	$C_{42}H_{33}N_3$	86.9	6.0	7.2	85.8	5.9	7.5
XIX	XIII, XVIII	134-135	$C_{42}H_{35}N_3$	86.8	6.0	7.2	86.8	6.2	7.5

ing overnight, 60 g. (82%) of product had separated. When treated quantitatively with methylmagnesium iodide, there was neither gas evolution nor addition. The properties of the tetrahydrocinnolines are collected in Table I.

The two products previously described, formed when phenylhydrazine was employed,[3] have now been identified. The one, m.p. 225–226°, is the triphenyltetrahydrocinnoline (IV), but its melting point was raised to 250–251° by recrystallization from xylene–ligroin; it shows one active hydrogen with methylmagnesium iodide. In chloroform solution, the addition of bromine gives a blue color, and hydrogen bromide is soon copiously evolved. The second product, m.p. 236°, is the same triphenyl derivative containing pyridine of crystallization.

Anal. Calcd. for $C_{26}H_{22}N \cdot C_5H_5N$: C, 84.6; H, 5.9; N, 9.5. Found: C, 84.3; H, 6.4; N, 9.4.

Dehydrogenations of Tetrahydrocinnolines. A. By Palladized Charcoal.—A mixture of 12 g. of 3,4-diphenyl-5,6,7,8-tetrahydrocinnoline (XXV) and 1 g. of palladized charcoal was slowly heated to 360–370°; there was a copious evolution of ammonia. After five hours at 370°, the mixture was distilled; 10.3 g. of distillate, b.p. 265–273° (10 mm.), was collected. While still hot, it was added to isopropyl alcohol and allowed to stand for 16 hours; 3.2 g. of solid was removed and recrystallized from alcohol. [This was the isomeric diphenylcinnoline (XII).] The solvent was removed from the filtrate and the residue was distilled, b.p. 266–270° (10 mm.); the distillate was added to alcohol (blue fluorescent solution), and, on standing, 5.4 g. of 2,3-diphenylindole separated. It melted at 123–124°, and there was no depression on admixture with an authentic specimen.[8]

When the dehydrogenation was carried out at 260° or in boiling cymene, a yellow 1:1 complex of 3,4-diphenylcinnoline and 2,3-diphenylindole separated from an isopropyl alcohol solution; the free indole also was obtained.

Anal. Calcd. for $C_{40}H_{29}N_3$: C, 87.0; H, 5.3; N, 7.6. Found: C, 87.2; H, 5.2; N, 7.5.

The indole could be separated from the complex as its picrate. When methyl iodide was added to a nitrobenzene solution of the complex, 3,4-diphenylcinnoline methiodide (XI) crystallized after standing for two days (see Table VI).

B. **Action of Selenium.**—A mixture of 10 g. of the tetrahydrocinnoline (XXV) and 5.5 g. of selenium was heated at 230° for two hours, and then at 310–320° for the same time. The results were essentially the same as those obtained by dehydrogenating in boiling cymene (see above).

C. **7-Methyl-3,4-diphenyl-5,6,7,8-tetrahydrocinnoline (XXVII)** was dehydrogenated with palladized charcoal, and worked up essentially as in A; the products mentioned in the introduction were separated with some difficulty. The other tetrahydrocinnolines were handled similarly. The properties of the various classes of products are collected in Table II.

7-Methyl-3,4-diphenyl-1,4-dihydrocinnoline (XV) was prepared by reducing the corresponding cinnoline (XIV) in absolute alcohol, using Adams catalyst at 70° for 12 minutes. It melted at 150°, and did not form a picrate. The unmethylated substance XXIIa was prepared similarly.

Anal. Calcd. for $C_{21}H_{18}N_2$: C, 84.4; H, 6.1; N, 9.4. Found: C, 84.2; H, 6.3; N, 9.2.

This dihydro derivative was the only product formed when the tetrahydrocinnoline (XXVII) was dehydrogen-

TABLE IV

PROPERTIES OF CINNOLINES

No.	3,4-Diphenyl	M.p., °C.	Empirical formula	Analyses, % Calcd. C	H	N	Found C	H	N
XXVIII	Unsubstituted[b]	151–152	$C_{20}H_{14}N_2$	85.0	5.0		85.4	4.8	
XIV	7-Methyl[b]	178	$C_{21}H_{16}N_2$	85.1	5.5	9.5	85.2	5.7	9.3
	Picrate of XIV	155	$C_{27}H_{19}N_5O_7$	61.7	3.6	13.3	61.8	3.8	13.2
XXI	8-Methyl[b]	158	$C_{21}H_{16}N_2$	85.1	5.5	9.5	85.3	5.5	9.7
VII	7,8-Benzo	182	$C_{24}H_{16}N_2$	86.7	4.8		86.2	4.8	
	Picrate[b] of VII	174	$C_{30}H_{19}N_5O_7$	64.2	3.4	12.5	64.3	3.7	12.4
	3,5(?)-Diphenyl								
XII	Unsubstituted[a]	123	$C_{20}H_{14}N_2$	85.0	5.0	9.9	84.9	5.5	9.9
	Picrate of XII[b,c]	164–165	$C_{26}H_{19}N_5O_7$	60.9	3.7	13.6	60.8	3.7	13.6
XXIX	6-Methyl[a]	183	$C_{21}H_{16}N_2$	85.1	5.5	9.5	85.2	5.5	9.7
	Picrate of XXIX[b,c]	181–182	$C_{27}H_{19}N_5O_7$	61.7	3.6	13.3	61.2	4.1	13.2
XXX	7-Methyl[a]	170	$C_{21}H_{16}N_2$	85.1	5.5	9.5	85.0	5.6	9.4
	Picrate of XXX[b,c]	194–195	$C_{27}H_{19}N_5O_7$	61.7	3.6	13.3	61.7	4.0	13.4

[a] Nearly colorless. [b] Yellow. [c] From alcohol.

TABLE V

PROPERTIES OF DIHYDROCINNOLINES

No.	M.p., °C.	Empirical formula	Analyses, % Calcd. C	H	N	Found C	H	N
XXIIa	129–130	$C_{20}H_{16}N_2$[a]	84.5	5.6	9.9	84.4	5.3	9.7
XV	150	$C_{21}H_{18}N_2$[a]	84.4	6.1	9.4	84.2	6.3	9.2
VI	230	$C_{24}H_{18}N_2$	86.4	5.4		86.1	5.4	
Picrate of VI	188	$C_{30}H_{21}N_5O_7$	63.9	4.4	12.4	64.2	4.0	12.6

[a] Shows one active hydrogen, no addition.

TABLE VI

PROPERTIES OF QUATERNARY SALTS

No.		M.p., °C.	Empirical formula	Analyses, % Calcd. C	H	N	Found C	H	N
	Methiodide of XXVIII	246 dec.	$C_{21}H_{17}IN_2$	59.4	4.0		59.4	3.9	
	Methiodide of XXVII	238	$C_{22}H_{23}IN_2$	60.0	5.2	6.3	59.7	5.2	6.2
XXXI	Methoperchlorate of III (R = H)	205-206 dec.	$C_{21}H_{21}ClN_2O_4$	63.0	5.3		62.0	5.5	
XXXII	Methoperchlorate of XXVII	208-209	$C_{22}H_{23}ClN_2O_4$	63.8	5.6	6.8	63.6	6.1	6.8

ated in boiling cymene for 8 hours following Fieser's procedure.[10]

In all instances, the various cinnolines were purified, converted to picrates, and then regenerated to insure homogeneity and identity. Toward the end of the work, the mixture, after dehydrogenation, was at once converted into a mixture of picrates, which were more easily separated than the bases.

Quaternary Salts.—The addition of alkyl halides to the cinnolines, using excess halide as a solvent, did not give a clean product. In these instances, the use of iodides seemed preferable for quaternarizing, but it was desirable to isolate the salts as perchlorates.[11] Methyl iodide added well in nitrobenzene, as already described. The iodides form black needles, that are red under moderate magnification and yellow when highly magnified or crushed to a powder.

None of the indoles gave quaternary salts, but readily formed bright yellow picrates.

3,4-Diphenyl-1-methyl-5,6,7,8-tetrahydrocinnolinium Perchlorate (XXXI).—A solution of 1.4 g. of the base (III, R = H) in 14 ml. of methyl iodide was refluxed for 24 hours; it turned red almost immediately. At the end of the refluxing, addition of water caused the separation of a viscous red oil. This was taken up in 50% alcohol, treated with Darco, filtered and an aqueous solution of 3 g. of sodium perchlorate was added. After standing for several days, the dark crystals that had separated were removed, taken up in methanol, treated with Darco, and allowed to crystallize. The yield of yellow needles, which darkened at about 200° and had an m.p. 205–206°, with decomposition, was 0.1 g. This perchlorate showed a light greenish-yellow fluorescence when illuminated by ultraviolet light.

The perchlorate (XXXII) of the 7-methyl homolog showed a bluish-white fluorescence and was obtained in a yield of 1.1 g.; the 8-methyl homolog gave a perchlorate, m.p. 207–210°, with decomposition.

Decamethylene-bis-3,4-diphenyl-5,6,7,8-tetrahydrocinnolinium perchlorate was prepared by refluxing a benzene (15 ml.) solution of 1.4 g. of the base and 1 g. of decamethylene iodide for 24 hours, removing the solvent *in vacuo*, taking up the residue in methanol, and adding a methanolic solution of 3 g. of sodium perchlorate. After considerable manipulation, including treatment with Darco, a viscous oil separated; the latter slowly crystallized, as a light brown powder, in a yield of 2.1 g. It softened at about 110° and melted, with decomposition, at 120–130°.

Anal. Calcd. for $C_{50}H_{56}Cl_2N_4O_8$: C, 65.7; H, 6.2; N, 6.1. Found: C, 64.5; H, 7.0; N, 6.7.

The 7-methyl homolog behaved similarly; it softened at 100–105°, and melted, with decomposition, at 115–125°.

Anal. Calcd. for $C_{52}H_{60}Cl_2N_4O_8$: C, 66.5; H, 6.4; N, 6.0. Found: C, 65.2; H, 6.2; N, 7.2.

Benzil Monophenylhydrazone.—Although this substance is not new, its preparation did not proceed readily by the published procedures,[12,13] owing to contamination with osazone. The use of an ester column and removal of the water azeotropically with benzene, was very satisfactory. A solution of 77 g. of phenylhydrazine in 150 ml. of benzene was added slowly to a refluxing solution of 156 g. of benzil in 750 ml. of benzene. After 13 ml. of water had been collected, 500 ml. of benzene was distilled through the column; 1 l. of ligroin (b.p. 90–100°) was added. After the mixture had been allowed to stand for two days, 116 g. of hydrazone was collected, m.p. 133–135°; a second crop, 73 g. (m.p. 128–131°), resulted on partial spontaneous evaporation.

For the cyclization, 20 g. of the hydrazone was added slowly to 200 ml. of concentrated sulfuric acid at −20° (solid Dry Ice was added), with stirring; after the solution was brought to room temperature (about two hours), it was

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(10) L. F. Fieser, "Experiments in Organic Chemistry," 2nd Ed., D. C. Heath & Co., Boston, Mass., 1941, p. 463.

(11) We are indebted to Dr. F. W. Spangler, of these laboratories, for the preparation of the perchlorates.

(12) C. Bülow, *Ann.*, 236, 197 (1886).

(13) E. Bamberger and J. Grob, *Ber.*, 34, 531 (1901).

poured upon 300 g. of ice. The precipitate was taken up in methanol and the solution mixed with dilute sodium hydroxide; the insoluble portion was extracted with ether, which gave 7 g. of crude cinnoline. After distillation and crystallization, 5.5 g. of pure 3,4-diphenylcinnoline (XXVIII), m.p. 151–152°, was obtained (Table IV). The water-soluble portion was a sulfonated benzil hydrazone, as is evident by a comparison of the ultraviolet absorption curves (Fig. 3).

An attempt to cyclize the monophenylhydrazone of phenylglyoxal gave only sulfonation.[14]

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(14) This work was done by G. A. Reynolds, of these laboratories.

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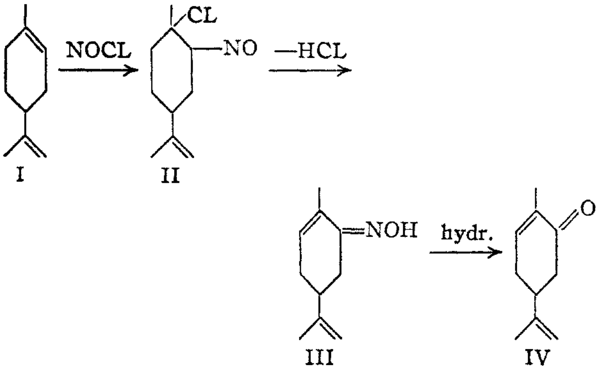
[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, EMORY UNIVERSITY]

Conversion of *d*-Limonene to *l*-Carvone[1]

BY E. EARL ROYALS AND SAMUEL E. HORNE, JR.

d-Limonene has been converted into *l*-carvone in over-all yield of 56–60%. *d*-Limonene was converted to the nitrosochloride by the action of ethyl nitrite and hydrogen chloride in ethyl alcohol solution at −5°; the yield was 80%. *d*-Limonene nitrosochloride was dehydrohalogenated to *l*-carvoxime in 90–95% yield by the action of pyridine. Hydrolysis of *l*-carvoxime by refluxing with 5% aqueous oxalic acid under carefully controlled conditions gave *l*-carvone in 78–80% yield.

The conversion of *d*-limonene (I) into *l*-carvone (IV) through the intermediates of *d*-limonene nitrosochloride (II) and *l*-carvoxime (III) was of crucial importance to the determination of the structure of limonene, α-terpineol, terpin and carvone.[2] The conversion of *d*-limonene to the nitrosochloride has been effected by the action of gaseous nitrosyl chloride[3] and by the action of ethyl nitrite,[4] amyl nitrite[4] or nitrogen trioxide[5] in the presence of hydrogen chloride. We have found all of these procedures, as described in the literature, unsuited to the large scale preparation of the nitrosochloride in good yield. Alcohol,[6] alcoholic alkali,[7] sodium methoxide[8] and pyridine[9] have been used for the dehydrohalogenation of *d*-limonene nitrosochloride to *l*-carvoxime. Until quite recently[10] the hydrolysis of *l*-carvoxime to *l*-carvone has received no attention, at least from the preparative viewpoint. After completion of the present work there appeared a report[10] of the preparation of *l*-carvone in 35% over-all yield from *d*-limonene on pilot plant scale utilizing the intermediates II and III. That work differs considerably in detail from the procedures described herein.



The principal contributions of the present work are the development of satisfactory procedures for the conversions of I to II and of III to IV. Satisfactory preparative procedures for these steps, described in detail in the experimental section, have been developed permitting an over-all yield of 56–60% for the conversion of *d*-limonene to *l*-carvone. Gaseous ethyl nitrite, generated by the action of aqueous alcoholic sulfuric acid on sodium nitrite, was passed into *d*-limonene in alcohol solution at −5°; treatment of the resulting solution at −5° with moist hydrogen chloride in the presence of a small amount of water afforded *d*-limonene nitrosochloride in 80% yield. Dehydrohalogenation to *l*-carvoxime was effected by the pyridine procedure of Wallach[9] in 90–95% yield. Hydrolysis of *l*-carvoxime to *l*-carvone without racemization or isomerization was readily effected in 78–80% yield by refluxing with 5% aqueous oxalic acid. The use of dilute (5 *N*) mineral acids led to the formation of carvacrol as the major hydrolysis product. It is interesting to note that 5% oxalic acid has a *p*H of approximately 0.7, the same as the most favorable value reported[10] by Bordence, Allison and Dirstine.

Experimental

Preparation of *d*-Limonene Nitrosochloride.—The method of Wallach[4] was found to be quite suitable for the preparation of *d*-limonene nitrosochloride on a small scale. In our hands, the yields on 0.06 molar scale ranged from 32 to 60% depending upon the temperature of reaction. In general, the yield increased with lower reaction temperature. Quite small yields were obtained when attempt was made to scale up this procedure. Similarly, the procedures of Tilden[3] and of Rupe[5] gave quite low yields of *d*-limonene nitrosochloride on 0.5 molar scale (8–11 and 16%, respectively).

The following procedure was found quite suitable to the preparation of *d*-limonene nitrosochloride on 0.5 molar scale. A mixture of 68.1 g. (0.5 mole) of *d*-limonene and 85 ml. of ethyl alcohol was placed in a 500-ml., three-necked flask equipped with a mechanical stirrer, a thermometer and a gas inlet tube. The flask was surrounded by an ice–salt freezing mixture, and the contents were cooled to −10°. Gaseous ethyl nitrite was passed into the limonene solution while maintaining a temperature of −8 to −10°. The ethyl nitrite was generated by dropping a mixture of 32.2

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(1) This paper is taken from a thesis presented by Samuel E. Horne, Jr., to the Graduate Faculty of Emory University in partial fulfillment of the requirements for the degree of Doctor of Philosophy, August 30, 1950.

(2) H. Goldschmidt and R. Zurrer, *Ber.*, **18**, 1729 (1885); G. Wagner, *ibid.*, **27**, 2270 (1894).

(3) W. A. Tilden and W. A. Shenstone, *J. Chem. Soc.*, **31**, 554 (1877).

(4) O. Wallach, *Ann.*, **245**, 255 (1888); *ibid.*, **252**, 109 (1889).

(5) H. Rupe, *Helv. Chim. Acta*, **4**, 149 (1921).

(6) H. Goldschmidt and R. Zurrer, *Ber.*, **18**, 2220 (1885).

(7) O. Wallach, *Ann.*, **246**, 227 (1888); *ibid.*, **270**, 175 (1892).

(8) A. Hahn, *ibid.*, **369**, 60 (1909).

(9) O. Wallach, *ibid.*, **414**, 257 (1918).

(10) C. Bordence, R. K. Allison and P. H. Dirstine, *Ind. Eng. Chem.*, **43**, 1196 (1951).