pound, when compared with the extinction coefficients for trifluoromethyl benzene and *bis*(trifluoromethyl)benzene, is in the expected range. The ultraviolet curve showed a smoothing out effect with an electron donating solvent such as ether when compared with the spectrum determined in chloroform. The inductive effect of the eighteen fluorine atoms would be expected to make the ring very electron deficient and could account for this phenomenon.

The solubility characteristics of the trimer are appropriate to an electron deficient structure, as it has a low solubility in benzene but is soluble in electron rich solvents. A solubility in tetrahydrofuran greater than that in ethyl ether is consistent with the greater basicity of the former.

The melting point of the perfluorobutyne trimer is in the range expected for hexa (trifluoromethyl)-benzene. A plot of the melting points of the methylbenzenes *vs.* the melting points of the known trifluoromethylbenzenes is linear.

All the evidence shown above is based on the physical properties of the trimer and substantiates the proposed aromatic ring structure. We would like to report, in addition, that unequivocal chemical confirmation of the ring structure was obtained by vapor phase chlorination of the trimer under ultraviolet irradiation to produce chlorotrifluoromethane and hexachlorobenzene.

Preparation of hexa(trifluoromethyl)benzene has been modified to include a relatively cold reservoir in the pyrolysis tube for condensation of the product as formed. Yields of 68% of the resublimed or recrystallized product have been obtained.

Further work on reactions of hexa(trifluoromethyl)benzene promoted by free radical attack and also by the attack of nucleophilic reagents is in progress.

EXPERIMENTAL

Hexa(trifluoromethyl)benzene. Hexafluorobutyne-2 (20 g., 0.123 mol.) was condensed into a previously evacuated heavy wall Pyrex tube 55 cm. × 2.4 cm. designed to project from a vertical tube furnace approximately 6 in. The tube was then sealed and heated at 375° for 60 hr. The autogenous pressure in the 250 ml. tube was calculated to be about 25 atm. As the reaction proceeded, the solid product condensed in the exposed, relatively cool portion of the tube. The tube was cooled, opened, and the condensed solid removed and resublimed. Recrystallization from carbon tetrachloride gave 13.7 g. (68.5%) of pure hexa(trifluoromethyl)benzene, m.p. 209° (sealed tube).

Chlorination of hexa(trifluoromethyl)benzene. Hexa(trifluoromethyl)benzene (4.86 g., 0.01 mol.) was placed in a 500 cc. Vycor flask. Dry chlorine gas, 4.4 g. (0.062 mol.), was condensed into the flask, and the flask was sealed and heated to 260° under ultraviolet radiation supplied by a Hanovia utility lamp for 44 hr. The vessel was cooled and opened into a vacuum system to remove the volatile material which was subsequently bubbled through a 10% solution of sodium hydroxide to remove any unreacted chlorine. The remaining gas was identified by molecular weight determination (Dumas-104) and infrared spectra as chlorotrifluoromethane. The solid product was recrystallized from benzene to give pure hexachlorobenzene, m.p. 229–230°, mixed melting point with authentic samples 229–231°. The infrared spectra of this solid material also corresponded to that of an authentic sample of hexachlorobenzene.

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Quebrachamine. II

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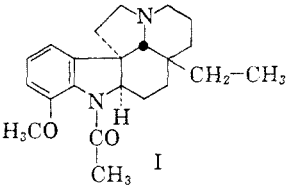
The establishment by x-ray analysis of the structure I for aspidospermine[1–3] makes II an attractive



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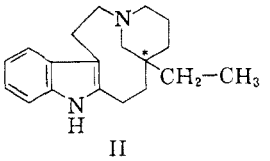


II

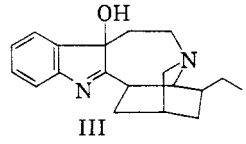
formulation for quebrachamine.[4] This note reports two further experiments designed to clarify the nature of the substituent, H or R, at the α-indole position, and identifies the "*N*(*a*)-acetyldihydroindole base" previously reported,[4] as I.

The positive Ehrlich and Hopkins-Cole reactions of quebrachamine suggested an α-unsubstituted indole ring. Such α-unsubstituted indoles may be characterized or diagnosed by their α,α′-disulfides. Quebrachamine trichloroacetate reacted in benzene with disulfur dichloride to yield a crystalline disulfide, whose ultraviolet absorption peak showed the expected shift to longer wave lengths.[5] Reductive hydrolysis, however, gave back quebrachamine. It must be concluded that quebrachamine disulfide is an abnormal disulfide in which two molecules of quebrachamine are linked together by an S-S bridge attached to an unknown position of the indole part. Tetrahydrocarbazole did not yield a disulfide.

Another reaction characteristic of α-unsubstituted indoles is their oxidation to (di)oxindole derivatives with *N*-bromosuccinimide.[6] Quebrachamine under such conditions gave a tribromo com-

(1) S. C. Nyburg and J. F. D. Mills, *Tetrahedron Letters*, **11**, 1 (1959).
(2) G. F. Smith and J. T. Wrobel, *J. Chem. Soc.*, in press.
(3) H. Conroy, P. R. Brook, and Y. Amiel, *Tetrahedron Letters*, **11**, 4 (1959).
(4) *Cf.* B. Witkop, *J. Am. Chem. Soc.*, **79**, 3193 (1957).
(5) *Cf.* K. Freter, J. Axelrod, and B. Witkop, *J. Am. Chem. Soc.*, **79**, 319 (1957).
(6) A. Patchornik, W. B. Lawson, and B. Witkop, *J. Am. Chem. Soc.*, **80**, 4747 (1958).

pound $C_{19}H_{23}N_2Br_3$, m.p. 290°, whose ultraviolet spectrum (Table I) was similar to that of the hydroxy base $C_{19}H_{26}N_2O$, m.p. 188°. Both these compounds have peaks similar to, but extinctions higher than, the β-hydroxyindolenine III derived from ibogamine (Table I).[7] This type of spectrum, intermediate between indole and indolenine, may



III

point to transannular interaction with N_b. No definite structures are assigned to these products at this time. The failure of *N*-bromosuccinimide to convert quebrachamine to an oxindole derivative is proof for an α-substituted indole nucleus. This is in agreement with the results of recent studies of the nuclear magnetic resonance spectrum of quebrachamine[8] which clearly shows the absence of the peak characteristic of the proton in the α-position of the indole ring.

TABLE I

ULTRAVIOLET SPECTRA IN 95% ETHANOL

Compound	λ_{max}	ε
Hydroxy base $C_{19}H_{26}N_2O$, m.p. 188°, from quebrachamine	295	7,080
	286	7,590
	227	28,200
Tribromo compound $C_{19}H_{23}N_2Br_3$, m.p. 290°, from quebrachamine	293	7,470
	285	7,440
	231	44,000
Hydroxyindolenine III from ibogamine	292	3,020
	281	3,200
	253–254	3,910
	228	13,700
	222	19,800

The same study led to the conclusion that the NMR peaks of possible indolenine tautomers of cycloheptenoindole, cyclooctenoindole and of II, a cyclononenoindole, would be masked by the multiplicity of saturated methylene protons.

The so-called "*N*(*a*)-acetyldihydroindole base," m.p. 213°,[4] and the "isomeric hydroxy base," m.p. 103°,[4] turned out to be aspidospermine and deacetylaspidospermine.[9] Apparently the latter is admixed with samples of "pure" quebrachamine, m.p. 144°, which give a single spot on chromatograms in three different solvent systems. Repeated recrystallization gave a sample, m.p. 145–146°, $[\alpha]_D^{20}$ −116.5°, which with hydrogen peroxide in acetic acid gave solely the hydroxy base, m.p. 188°.

(7) D. F. Dickel, C. L. Holden, R. C. Maxfield, L. E. Paszek, and W. I. Taylor, *J. Org. Chem.*, **80**, 123 (1958).

(8) L. A. Cohen, J. W. Daly, H. Kny, and B. Witkop, *J. Am. Chem. Soc.*, in press.

(9) We are greatly indebted to Prof. H. Conroy for pointing out first these possibilities.

EXPERIMENTAL[10]

Fractional recrystallization of quebrachamine. A sample of quebrachamine (5 g.) obtained through the courtesy of E. Merck, Darmstadt,[11] was recrystallized twice from methanol and showed then m.p. 143–145°, $[\alpha]_D^{20}$ −117.3° (*c*, 1.0 in 95% C_2H_5). Further recrystallizations from cyclohexane furnished 5 fractions of increasing solubility which had the following melting points: 145–146°; 145–146°; 146–147°; 145–146°; 144–145°. The rotations of the first four fractions were all $[\alpha]_D^{20}$ −116.5 ± 2°. The last fraction and mother liquors had $[\alpha]_D^{20}$ −118.8 ± 2° which slowly increased on standing in solution, since the hydroxy base $C_{19}N_{26}N_2O$, $[\alpha]_D^{20}$ −504°, is formed.

Chromatographic analysis. In three solvent systems (a) 2-butanol–formic acid–water (75:15:10), (b) 99% of a mixture of 2 parts of methanol, 1 part of benzene, 1 part of 1-butanol and 1 part of water, and 1% of a 15% aq. ammonia solution, (c) phenol–formic acid–water (120 g.:1.6 cc.:40 cc.) quebrachamine traveled close to the solvent front (Whatman No. 1 filter paper) showing R_f values >0.9. Deacetylaspidospermine was indistinguishable in these systems. In amyl alcohol–water (90:6) there was a slight separation of quebrachamine (R_f 0.92) and deacetylaspidospermine (0.83) which however was insufficient to detect 10% deacetylaspidospermine in a mixture made up with quebrachamine. The use of filter paper impregnated with borate buffer of *p*H 7.4, 9.3, and 10.4 did not improve the separation.

Electropherograms[12] of mother liquors of quebrachamine in acidic buffer systems showed the presence of small amounts of oxy base $C_{19}H_{26}N_2O$, m.p. 188°, which moved slightly faster than quebrachamine. Deacetylaspidospermine moved (after 50 min.) approximately twice as fast as quebrachamine and was detectable by its coloration on spraying with 1% ethanolic cinnamaldehyde solution and subsequent exposure to hydrogen chloride gas. In mixtures made up of 50% quebrachamine and 50% deacetylaspidospermine separation and detection were still possible, but 10% deacetylaspidospermine admixed to quebrachamine could not be detected in this way.

Identification of "base $C_{21}H_{28}N_2O_2$, m.p. 213°" with aspidospermine. By the action of 6 cc. of acetic acid–30% hydrogen peroxide (1:1) on 0.5 g. of commercial "pure" quebrachamine 40 mg. of the base considered to be an N^a-acetylhydroxy- derivative $C_{21}H_{28}N_2O_2$ of quebrachamine was obtained.[4] The mixed melting point of this base with aspidospermine ($C_{22}H_{30}N_2O_2$) was 213°. The ultraviolet and infrared spectra of the two bases were identical. No aspidospermine was found when the purest sample of quebrachamine obtained by repeated recrystallizations first from methanol and then from cyclohexane was oxidized with peracetic acid. This led only to the formation of the base $C_{19}H_{26}N_2O$, m.p. 188°.

Quebrachamine disulfide. To a cooled solution of 29.2 mg. of quebrachamine in 10 ml. of anhydrous benzene was added 100 mg. of anhydrous trichloroacetic acid and 1 ml. of a solution of 6.8 mg. of disulfur dichloride (S_2Cl_2) in benzene. After 2 hr. the reaction mixture was poured into an excess (*ca.* 100 ml.) of petroleum ether (b.p. 30–40°). The precipitate was removed by centrifugation, washed with ether and petroleum ether, and recrystallized from petroleum ether to colorless crystals (20 mg., 60%), m.p. 166°; R_f 0.25, compared with quebrachamine 0.8 (2,4-lutidine-*t*-amyl alcohol, 1:1, saturated with water). The reactions according to Ehrlich, Hopkins-Cole and with cinnamic aldehyde were

(10) All melting points are corrected. The analyses were performed by the Analytical Services Unit of this laboratory, under the direction of Dr. W. C. Alford.

(11) We are greatly indebted to Dr. Jan Thesing for his assistance and cooperation.

(12) Approximately 50 volts/cm., using the Wieland-Pfleiderer Pherograph [*cf. Angew. Chem.*, **67**, 257 (1955)].

all negative. The Keller reaction, concd. sulfuric acid containing a trace of ferric ion, was positive.

Anal. Calcd. for $C_{33}H_{50}N_4S_2$: C, 72.79; H, 7.99; N, 8.94; S, 10.23. Found: C, 72.50; H, 8.04; N, 9.06; S, 10.33.

Ultraviolet spectrum: λ_{max} (log ϵ) 300 (3.56); 212 (4.30).

Infrared spectrum (potassium bromide): 2.95–2.98 (broad); 3.43; 3.58; 6.05vw; 6.20vw; 6.44s; 6.86vs; 7.25m; 7.39s; 7.52w; 7.86m; 8.10m; 8.28m; 8.39s; 8.56w; 8.74m; 8.86m; 9.08w; 9.37w; 9.74m; 9.88m; 10.0vw; 10.11vw; 10.36m; 10.69w; 11.51m μ.

On reductive hydrolysis of the disulfide (10 mg.) with zinc in acetic acid the ether solution of the crude reaction product showed (in chloroform) a band at 5.81 μ of medium intensity, and 6.20vs, both bands typical of oxindole derivatives. However, on purification of the material *via* the picrate only a small amount of quebrachamine picrate, m.p. 193°, identified by mixed melting point and infrared spectrum, was obtained. The same result was given by the reduction of the disulfide with Raney nickel.

Quebrachamine "tribromide." *N*-Bromosuccinimide (0.222 g.) was added slowly with mechanical stirring to 0.141 g. of quebrachamine in 3 ml. of glacial acetic acid and 2 ml. of water. Stirring was continued for 1 hr. at room temperature and then 4*N* sodium hydroxide was added in the cold until the solution was at *p*H 6. Extraction with dichloromethane and *n*-propyl alcohol yielded a yellow oil which was crystallized from chloroform and benzene to yield 0.08 g. of cotton-like needles, m.p. 287–289°. The analytical sample was prepared by a recrystallization from the same solvents. It displayed m.p. 290°, ultraviolet spectrum λ_{max} 231 (ϵ 44,000), 285 (ϵ 7,440), 293 (ϵ 7,470) and had no carbonyl absorption in the infrared.

Anal. Calcd. for $C_{19}H_{23}N_2Br_3$: C, 43.96; H, 4.47; Br, 46.18. Found: C, 43.99; H, 4.59; Br, 45.99. The formula $C_{19}H_{25}N_2Br_3$ (C, 43.79; H, 4.84; Br, 46.00) is not excluded.

Acknowledgment. We are greatly indebted to Drs. K. Freter and A. A. Patchett for experimental assistance, to Dr. H. Conroy for helpful discussions and to Dr. G. F. Smith for an advance copy of his manuscript prior to publication.

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Synthesis of 9-Methyl-3,9-diazabicyclo[4.2.1]-nonane

R. J. MICHAELS AND H. E. ZAUGG

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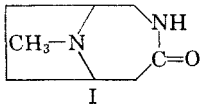
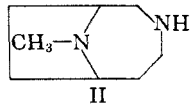
This note reports the preparation of the title compound, II, by treatment of tropinone with hydrazoic acid to give the bicyclic lactam I which was reduced with lithium aluminum hydride. The overall yield of II was 61%.



I



II

This scheme provides access to a bicyclic homopiperazine system of potential value as an intermediate for compounds of pharmacological interest.

EXPERIMENTAL

9-Methyl-3,9-diazabicyclo[4.2.1]nonan-4-one (I). A solution of 11.1 g. (0.08 mole) of tropinone in 100 ml. of chloroform cooled to −5° in an ice-salt bath was treated dropwise with stirring with 25 ml. of concentrated sulfuric acid, keeping the temperature below 15°. After cooling to 5° the stirred reaction mixture was treated with 10.4 g. (0.16 mole) of sodium azide in approximately 0.5–1 g. portions at such a rate that the temperature did not exceed 35°. Addition of the azide required about 2 hr. after which the reaction mixture was stirred at 50° for another 2 hr. It was then poured into a 600 ml. beaker one third filled with ice. Solid potassium carbonate was added portionwise until the mixture was strongly alkaline. This was followed by 50 ml. of a 60% potassium hydroxide solution; the inorganic salts were removed by filtration and washed well with chloroform. The alkaline filtrate was extracted with three portions of chloroform and the combined chloroform washings and extracts were dried over anhydrous sodium sulfate. Filtration of the drying agent followed by removal of the chloroform by distillation gave 11.1 g. (90%) of crude I, m.p. 79–83°. For analysis, a sample was converted to the hydrochloride, m.p. 258–259° dec. (from ethanol).

Anal. Calcd. for $C_8H_{15}ClN_2O$: C, 50.39; H, 7.93; N, 14.69. Found: C, 50.42; H, 7.96; N, 14.59.

9-Methyl-3,9-diazabicyclo[4.2.1]nonane (II). To a solution of 11.0 g. (0.071 mole) of I in 400 ml. of dry ether was added dropwise with stirring under an atmosphere of dry nitrogen, a solution of 6.8 g. (0.18 mole) of lithium aluminum hydride in 200 ml. of dry ether. Addition was complete in 0.5 hr., and the mixture was stirred and refluxed for 46 hr.

Water (25 ml.) was added dropwise to the cooled reaction mixture which was then filtered by suction. The filter cake was washed well with ether and the combined filtrate and washings were dried over anhydrous sodium sulfate. Filtration and removal of the ether by distillation followed by vacuum distillation of the residual oil gave 6.8 g. (68%) of II, b.p. 111–113° (38 mm.), n_D^{24} 1.4992.

Anal. Calcd. for $C_8H_{16}N_2$: C, 68.52; H, 11.50; N, 19.98. Found: C, 68.71; H, 11.91; N, 20.26.

II.Dihydrochloride, m.p. 290–291° dec. (from dry ethanol).

Anal. Calcd. for $C_8H_{18}Cl_2N_2$: C, 45.08; H, 8.51. Found: C, 45.46; H, 8.61.

Acknowledgment. The authors are indebted to Mr. E. F. Shelberg and his associates for the microanalyses.

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Preparation of *m*- and *p*-Diethynylbenzenes

ALLAN S. HAY

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We wished to prepare reasonably large quantities of *m*- and *p*-diethynylbenzenes. Deluchat[1]

(1) R. Deluchat, *Ann. chim.*, 1 [11] 181–255 (1934).