NOTES

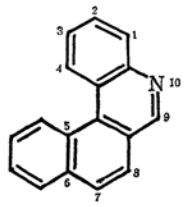
Synthesis of 5 : 6-Benzphenanthridines

V. KESAVAN, V. C. DEVANATHAN and N. ARUMUGAM

Department of Chemistry, Madurai University, Madurai-2, South India

(Received January 11, 1968)

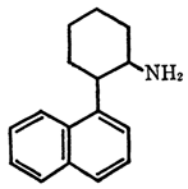
5:6-Benzphenanthridine (A) is one of the six benzphenanthridines possible depending upon the manner of fusion of a benzene ring to the phenanthridine nucleus.



A

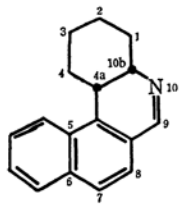
The synthesis of this benzphenanthridine nucleus has not received much attention. Mills and Schofield[1] reported the syntheses of a few 5 : 6-benzphenanthridines by cyclisation of 1-*O*-acylaminophenylnaphthalenes. But the handicap in this method, according to the above authors was the low yields of 1-(*o*-nitroaryl)naphthalenes from the Ullmann reaction of the relevant halo compounds. Brown and co-workers[2] recorded the synthesis of *N*-methyl-5:6-benzphenanthridone from 1-amino-*N*-methyl-2-naphthalide and the difficulty in this approach is stated to be the preparation of 1-amino-2-naphthoic acid. Keene and Schofield[3] had employed Schmidt reaction of benzofluorenone which resulted in the difficultly separable mixture of 3:4- and 5:6-benzphenanthridones. We report here the syntheses of a few 5:6-benzphenanthridines through the well known Bruckner method.[4]

Addition of dinitrogen trioxide to 1-(α-naphthyl)-cyclohexene yields according to the conditions 1-(α-naphthyl)-2-nitrocyclohexene and an alkali soluble compound (X), mp 210°C. This behaviour of 1-(α-naphthyl)-cyclohexene is similar to 1-phenyl- or 1-substituted phenylcyclohexenes.[5,6] The reduction of 1-(α-naphthyl)-2-nitrocyclohexene by lithium aluminum hydride gave the *cis*-2-(α-naphthyl)-cyclohexylamine (B) in good yields. The amino group in this amine is shown to be axial on the basis of the IR spectrum and comparison with the trans isomer.[7]



B

The formyl, acetyl and the benzoyl derivatives of this amine when cyclised with 4:5 phosphorus pentoxide-phosphoric acid mixture yielded the corresponding *cis*-1,2,3,4,4a,10b-hexahydro-5:6-benzphenanthridines (C).



C

The above hexahydrobenzphenanthridines on dehydrogenation over palladised charcoal in decalin yielded the fully aromatised 5:6-benzphenanthridines.

The 1-(4-methyl-1-naphthyl)-cyclohex-1-ene, 1-(4-methoxy-1-naphthyl)-cyclohex-1-ene and 1-(9'-phenanthryl)-cyclohexene when carried through a

1) B. Mills and K. Schofield, *J. Chem. Soc.*, **1956**, 4213.
2) D. N. Brown, D. H. Hey and C. W. Rees, *ibid.*, **1961**, 3873.
3) B. R. T. Keene and K. Schofield, *ibid.*, **1958**, 2609.
4) V. Bruckner, *Ann. Chem.*, **518**, 227 (1935); G. Bruckner Jr., G. V. Fodor, L. Bence and E. Borcsok, *Ber.* **76**, 466 (1943).
5) T. R. Govindachari, K. Nagarajan, B. R. Pai and N. Arumugam, *J. Chem. Soc.*, **1956**, 4280.
6) T. R. Govindachari, K. Nagarajan and V. N. Sundararajan, *Tetrahedron*, **15**, 60 (1961).
7) V. Kesavan and N. Arumugam, Paper accepted for publication, *Indian. J. Chem.*

TABLE 1. 1-SUBSTITUTED 2-NITROCYCLOHEXENES

Substituent at position 1	Mp (°C)	Molecular formula	Analysis % Calcd	Analysis % Found
(4-Methyl-1-naphthyl)-	90—91 (ether)	$C_{17}H_{17}NO_2$	C, 76.4 H, 6.4	C, 76.2 H, 6.2
(9′-Phenanthryl)-	146 (acetone)	$C_{20}H_{17}NO_2$	C, 79.2 H, 5.6	C, 79.2 H, 5.6
(4-Methoxy-1-naphthyl)-	Oil	—	—	—

TABLE 2. 2-SUBSTITUTED 3-NITROCYCLOHEX-2-EN-1-ONE OXIMES*

Substituent at position 2	Mp (°C)	Molecular formula	Analysis % Calcd	Analysis % Found
(4-Methyl-1-naphthyl)-	242 (decomp.) (ethanol)	$C_{17}H_{16}N_2O_3$	C, 68.9 H, 5.4	C, 68.6 H, 5.4
(4-Methoxy-1-naphthyl)-	234 (decomp.)	$C_{17}H_{16}N_2O_4$	C, 65.4 H, 5.1	C, 65.4 H, 5.3

* Bruckner addition to 1-(9′-phenanthryl)-cyclohexene did not yield analogous compound.

TABLE 3. ACYL DERIVATIVES OF *cis*-2-SUBSTITUTED CYCLOHEXYLAMINES

Substituent at position 2	Acyl group	Mp (°C)	Molecular formula	Analysis % Calcd	Analysis % Found	IR peak ν_{max} (KBr)
(4-Methyl-1-naphthyl)-	Acetyl	186 (benzene)	$C_{13}H_{23}NO$	C, 81.1 H, 8.2	C, 81.0 H, 8.3	3340 cm^{-1} 3060 cm^{-1}
	Benzoyl	138 (dil. ethanol)	$C_{24}H_{25}NO$	C, 83.8 H, 7.3	C, 83.5 H, 7.5	
(4-Methoxy-1-naphthyl)-	Acetyl	184 (benzene)	$C_{19}H_{23}NO_2$	C, 76.8 H, 7.8	C, 76.8 H, 7.9	3340 cm^{-1} 3060 cm^{-1}
(9′-Phenanthryl)-	Acetyl	237—238 (benzene)	$C_{22}H_{23}NO$	C, 83.3 H, 7.25	C, 83.0 H, 7.4	3340 cm^{-1} 3060 cm^{-1}
	Benzoyl	200 (alcohol)	$C_{27}H_{25}NO$	C, 85.6 H, 6.6	C, 85.5 H, 6.8	

similar series of reactions yielded (i) *cis*-7,9-dimethyl-1,2,3,4,4a,10b-hexahydro-5:6-benzphenanthridine, (ii) *cis*-7-methyl-9-phenyl-1,2,3,4,4*a*,10*b*-hexahydro-5:6-benzphenanthridine, (iii) *cis*-9-methyl-7-methoxy-1,2,3,4,4a,10b-hexahydro-5:6-benzphenanthridine, (iv) *cis*-9-methyl-1,2,3,4,4a,10b-hexahydro-5:6,7:8-dibenzphenanthridine and (v) *cis*-9-phenyl-1,2,3,4,4a,10b-hexahydro-5:6,7:8-dibenzphenanthridine. Compounds (i) and (iv) were aromatised to 7,9-dimethyl-5:6-benzphenanthridine and 9-methyl-5:6,7:8-dibenzphenanthridine. The ultraviolet spectra of 9-methyl- and 7,9-dimethyl-5:6-benzphenanthridines are recorded (Fig. 1).

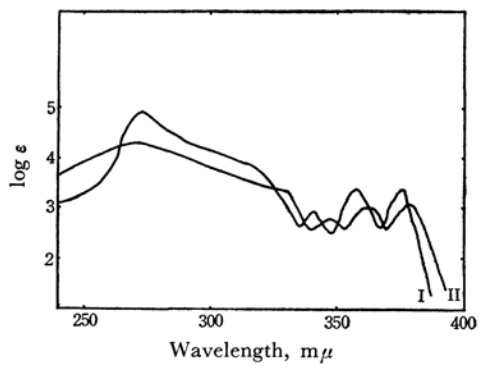


Fig. 1. Ultraviolet spectra of
i: 9-methyl-5:6-benzphenanthridine,
ii: 7,9-dimethyl-5:6-benzphenanthridine.

The compound (X), mp 210°C, mentioned earlier is regarded as 3-nitro-2-(α-naphthyl)-cyclohex-2-en-1-one oxime on the basis of the IR spectrum, and in analogy with the work of Govindachari *et al.*[6] This compound on hydrolysis gives a ketone which can be reconverted to the original compound (X) through hydroxylamine hydrochloride. It is inferred that the similar alkali soluble compcunds obtained from the addition of dinitrogen trioxide to 1-(4-methyl-1-naphthyl)-cyclohex-1-ene and 1-(4-methoxy-1-naphthyl)-cyclohex-1-ene possess structures similar to the compound (X).

TABLE 4. *cis*-1,2,3,4,4a,10b-HEXAHYDRO-5:6-BENZPHENANTHRIDINES

Substituent	Yield %	Mp (°C)	Molecular formula	Analysis % Calcd	Analysis % Found	Mp of picrate (°C)	Molecular formula	Analysis % Calcd	Analysis % Found
9-Methyl-	75	oil	—	—	—	223 (decomp.) (ethanol)	$C_{24}H_{22}N_4O_7$	C, 60.25 H, 4.6	C, 60.2 H, 4.4
9-Phenyl-	82	150—151 (ethanol)	$C_{23}H_{21}N$	C, 88.8 H, 6.7	C, 88.7 H, 7.0	234 (decomp.) (ethanol)	$C_{29}H_{24}N_4O_7$	C, 64.3 H, 4.6	C, 64.7 H, 4.4
7,9-Dimethyl-	63	oil	—	—	—	234 (decomp.) (ethanol)	$C_{25}H_{24}N_4O_7$	C, 61.0 H, 4.9	C, 61.3 H, 5.1
7-Methyl- 9-Phenyl-	64	165—166 (ethanol)	$C_{24}H_{23}N$	C, 88.6 H, 7.1	C, 88.2 H, 6.8	—	—	—	—
7-Methoxy-9-phenyl**	20	oil	—	—	—	214 (decomp.) (ethanol)	$C_{25}H_{24}N_4O_8$	C, 59.0 H, 4.7	C, 59.2 H, 4.6
9-Methyl-7:8-benz-	83	108—110 (ethanol)	$C_{22}H_{21}N$	C, 88.3 H, 7.0	C, 88.2 H, 7.0	222 (decomp.) (ethanol)	$C_{28}H_{24}N_4O_7$	C, 63.5 H, 4.5	C, 63.5 H, 4.3
9-Phenyl-7:8-benz-	61	171 (ethanol)	$C_{27}H_{23}N$	C, 89.75 H, 6.5	C, 89.5 H, 6.5	—	—	—	—

** Cyclisation by the described procedure failed. Adding the acetyl derivative (1 g) in phosphorus oxychloride (5 m*l*) to a stirred mixture of phosphorus pentoxide (5 g) and phosphoric acid (5 m*l*) and heating to 100°C gave the cyclised product.

TABLE 5. 5:6-BENZPHENANTHRIDINES

Substituent	Mp (°C)	Molecular formula	Analysis % Calcd	Analysis % Found	UV spectrum λ_{max} mμ	UV spectrum log ε	Mp of picrate (°C)	Molecular formula	Analysis % Calcd	Analysis % Found
9-Methyl-	95—96 (benzene-pet. ether)	$C_{18}H_{13}N$	C, 88.9 H, 5.3	C, 88.9 H, 5.3	273 341 357 375	4.63 3.02 3.39 3.39	216 (decomp.) (ethanol)	$C_{24}H_{16}N_4O_7$	C, 61.0 H, 3.4	C, 61.2 H, 3.2
7,9-Dimethyl-	129—130 (ethanol)	$C_{19}H_{15}N$	C, 88.7 H, 5.8	C, 88.3 H, 6.0	273 348 361 380	4.3 2.8 3.0 3.1	243 (decomp.) (ethanol)	$C_{25}H_{18}N_4O_7$	C, 61.8 H, 4.0	C, 62.0 H, 4.0
9-Methyl- 7 : 8-benz-	143—144 (ethanol)	$C_{22}H_{15}N$	C, 90.1 H, 5.1	C, 89.7 H, 5.3	262 325 348 380	4.4 3.6 3.5 3.0	—	—	—	—

Experimental

All melting points are uncorrected. Ultraviolet spectra were taken in Hilger and Watts model 700. Infrared spectra were recorded in Perkin-Elmer model 421. Detailed experimental procedures are presented only for one representative sequence of reactions. All other sequences were conducted in a similar manner using appropriate quantities of reactants. The relevant data are given in tables.

1-(α-Naphthyl)-2-nitrocyclohexene. A mixture of saturated solution of sodium nitrite (50 m*l*) and 1-(α-naphthyl)-cyclohexene (3 g) in ether (50 m*l*) was cooled in ice water and treated with 4 N sulfuric acid in drops till the green colour changed to yellow. The ether layer was immediately separated, washed with water and dried. The combined ether extracts from ten such experiments were treated with sodium (10 g) in methanol (100 m*l*) with vigorous shaking, diluted with water and the basic aqueous layer was separated. The ether layer was washed with 10% sodium hydroxide till free from alkali soluble material, washed with water, dried (sodium sulfate) and evaporated to yield 1-(α-naphthyl)-2-nitrocyclohexene (20 g), mp 95°C (from ether). ν_{max} (KBr) 1640 (–C=C–), 1550 and 1350 cm^{-1} (–NO_2).

The alkaline extracts were cooled and acidified with concentrated hydrochloric acid to give 3-nitro-2-(α-naphthyl)-cyclohex-2-en-1-one oxime (8 g) mp 210°C (from ethanol).

Found: C, 67.8; H, 5.2%. Calcd for $C_{16}H_{14}N_2O_3$: C, 68.08; H, 5.0%.

ν_{max} (KBr) 3247 (–OH), 1640 (–C=N) and 1515 and 1337 cm^{-1} (–NO_2).

A suspension of the above oxime (3 g) in 4 N sulfuric acid (50 m*l*) and dioxane (30 m*l*) was refluxed for three hours. The mixture was poured onto ice, extracted with ether, dried (sodium sulfate) and evaporated to yield 3-nitro-2-(α-naphthyl)-cyclohex-2-en-1-one (1.5 g), mp 130—131°C (from methanol). This ketone (1 g) and hydroxylamine hydrochloride (1 g) in alcohol (5 m*l*) and pyridine (5 m*l*) refluxed for three hours gave the oxime, mp 210°C (from ethanol). Mixed mp with the 3-nitro-2-(α-naphthyl)-cyclohex-2-en-1-one oxime showed no depression.

***cis*-2-(α-Naphthyl)-cyclohexylamine.** To a stirred solution of lithium aluminum hydride (2 g) in ether was added gradually a solution of 1-(α-naphthyl)-2-nitrocyclohexene (5 g). The mixture was left at 30°C for twenty four hours, then decomposed with water. The ether layer was decanted and extracted repeatedly with 2 N hydrochloric acid. The combined acid extracts were cooled, made alkaline and extracted with ether. The extract on evaporation left *cis*-2-(α-naphthyl)-cyclohexylamine as an oil (3.5 g).

Formyl derivative, mp 160—162°C (from ethanol).

Found: C, 80.4; H, 7.5%. Calcd for $C_{17}H_{19}NO$: C, 80.61; H, 7.5%.

Acetyl derivative, mp 186°C (from benzene - light petroleum).

Found: C, 81.1; H, 7.6%. Calcd for $C_{18}H_{21}NO$: C, 80.9; H, 7.9%.

Benzoyl derivative, mp 165—166°C (from dilute ethanol).

Found: C, 83.9; H, 7.1%. Calcd for $C_{23}H_{23}NO$: C, 83.9; H, 7.0%.

ν_{max} (KBr) 3340 and 3060 cm^{-1} (NH association band for axial –NH).[8]

***cis*-1,2,3,4,4a,10b-Hexahydro-5:6-benzphenanthridine.** A mixture of *cis*-1-formamido-2-(α-naphthyl)-cyclohexane (1 g) and 4:5 phosphorus pentoxide-phosphoric acid (20 g) was heated on an oil bath for two hours at 160°C. The mixture was cooled, decomposed with ice, the aqueous layer made alkaline and extracted with ether. The base in the etheral layer after purification by one more passage through acid gave *cis*-1,2,3,4,4a,10b-hexahydro-5:6-benzphenanthridine as an oil (0.6 g). The picrate prepared in the usual manner was crystallised from alcohol as yellow needles. Mp 239°C (decomp.).

Found: C, 59.8; H, 4.5%. Calcd for $C_{23}H_{20}N_4O_7$: C, 59.5; H, 4.3%.

5:6-Benzphenanthridine. *cis*-1,2,3,4,4a,10b-Hexahydro-5:6-benzphenanthridine (1 g) was dehydrogenated over 30% palladised charcoal (0.5 g) in refluxing decalin (25 m*l*) during eight hours, in a current of nitrogen. The 5:6-benzphenanthridine crystallising from acetone had mp 108°C.

Found: C, 89.2, H, 5.0%. Calcd for $C_{17}H_{11}N$: C, 89.1; H, 4.9%.

λ_{max} 272, 341 and 376 mμ. (log ε 4.5, 3.0 and 3.2 respectively).

The picrate was crystallised from alcohol as yellow needles, mp 253°C (decomp).

Found: C, 60.2; H, 2.9%. Calcd for $C_{23}H_{14}N_4O_7$: C, 60.3; H, 3.1%.

Summary

Syntheses of 5:6-benzphenanthridine, 9-methyl- and 7,9-dimethyl-5:6-benzphenanthridine, 9-methyl-5:6,7:8-dibenzphenanthridine, *cis*-9-phenyl-, *cis*-7-methyl-9-phenyl- and *cis*-7-methoxy-9-phenyl-1,2,3,4,4a,10b-hexahydro-5:6-benz-phenanthridine and *cis*-9-phenyl-1,2,3,4,4a,10b-hexahydro-5:6,7:8-dibenzphenanthridine are reported.

We thank R. Balasubramanian, Department of Chemistry, University of Madras, and CIBA Research Centre, Bombay, for analyses and IR spectra. Our thanks are also due to Government of India and U. G. C. for a scholarship and a Fellowship to V. K. and V. C. D. respectively.

8) Z. Yoshida, *Tetrahedron Letters*, **1965**, 2757.