

Synthesis and Reactions of 12-Aryl-1,2,3,4-tetrahydro-6*H*-indazolo[2,1-*a*]benzotriazolium Hydroxide Inner Salts and 8,9,10,11-Tetrahydro-7,10,10-trimethyl-8-oxo-5*H*-indazolo[1,2-*a*]benzotriazolium Hydroxide Inner Salt

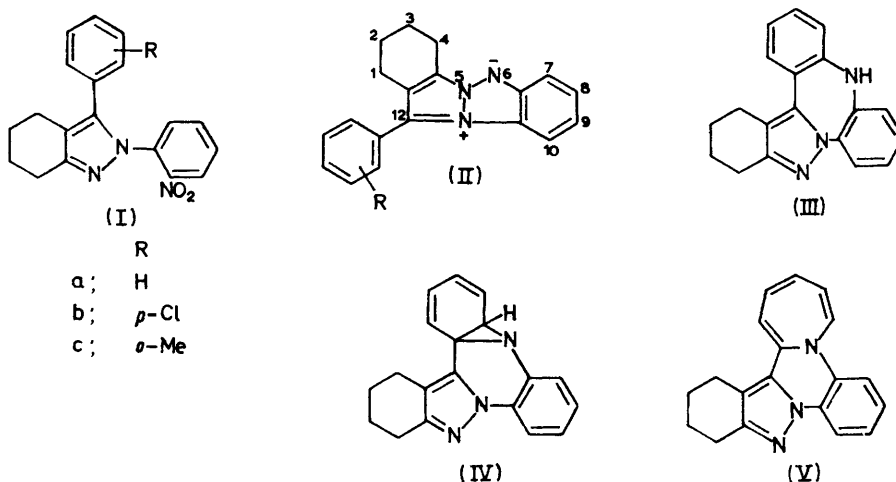
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Reductive deoxygenation of 3-aryl-4,5,6,7-tetrahydro-2-(*o*-nitrophenyl)indazoles in triethyl phosphite gave the corresponding triazapentalenes (II). The analogous reaction of 6,7-dihydro-3,6,6-trimethyl-1-(*o*-nitrophenyl)indazol-4(5*H*)-one yielded the trimethyltriazapentalenone (VII). These compounds did not undergo ready electrophilic substitution. 3-[1-Methyl-2-(*o*-nitrobenzylidene)hydrazino]cyclohex-2-enone (IX) in triethyl phosphite gave 3-[*N*-methyl(indazol-2-yl)amino]cyclohex-2-enone (XII).

THE reactions of 3-aryl-4,5,6,7-tetrahydro-2-(*o*-nitrophenyl)indazoles (I) in triethyl phosphite at 160° were investigated. The major product in each case was the triazapentalene inner salt (II). Products of interaction between the possible intermediate nitrene and the adjacent 3-aryl group [*e.g.* the diazepine (III) or the azepine (V)] were not detected.

presence of deuterium oxide. The properties of the triazapentalenes (IIa—c) are given in the Table.

The analogous reductive deoxygenation of 6,7-dihydro-3,6,6-trimethyl-1-(*o*-nitrophenyl)indazol-4(5*H*)-one (VI) in triethyl phosphite gave one characterisable product, identified as the triazapentalene inner salt (VII). Its i.r. spectrum, which was similar to those

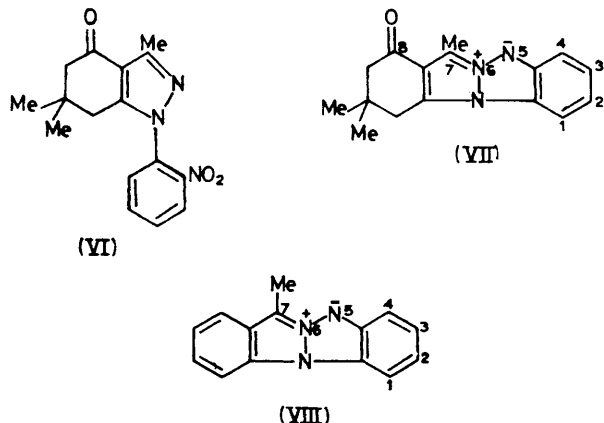


The i.r. spectrum of compound (IIa) showed no N-H bands, which ruled out structure (III), and the n.m.r. spectrum showed no olefinic azepine protons in the range τ 4—6, thus eliminating structure (V), which might have arisen by valence isomerisation of a spiro-intermediate (IV). In addition, the n.m.r. spectrum indicated that nine aromatic protons were present. Thus no substitution had taken place at the 3-phenyl group. Also no protons suffered exchange in the

of compounds (II), also showed an $\alpha\beta$ -unsaturated carbonyl band at 1673 cm^{-1} . Other properties are given in the Table.

It was expected that the properties of compounds (II) and (VII) would parallel those of the corresponding dibenzotriazapentalenes; however this was not exactly the case. For example, the n.m.r. spectra of solutions of (II) and (VII) in trifluoroacetic acid showed no proton incorporation at C-4a or -7, respectively.

Tsuge and Samura¹ found that the inner salt (VIII) showed a doublet *C*-methyl signal in trifluoroacetic acid and a new one-proton triplet signal, corresponding to a *C*-7 proton; thus our compounds appear to be less susceptible to electrophilic attack at this position.



The perchlorate salts of compounds (IIa) and (VII) were formed by addition of 60% perchloric acid to solutions in tetrahydrofuran; they were isolated by addition of an excess of ether. The n.m.r. spectrum

enes.² Thus an attempt to nitrate compound (IIa) under mild conditions (aqueous 10% nitric acid at room temperature for 3 h), which produced a dinitro-dibenzotriazapentalene in 50% yield and a mononitro-dibenzotetra-azapentalene (25% nitric acid overnight at 25°) in 91% yield, resulted in no reaction during 12 h; however after 24 h a red powder was obtained. T.l.c. showed this to be a complex mixture, only one component of which had a polarity comparable with that of the starting material (the others were more polar). Treatment with concentrated nitric acid at 0 °C produced an immediate reaction with formation of a red powder which again appeared to be a complex mixture.

Bromination of compound (IIa) in acetic acid yielded mainly a monobromo-derivative in 10% yield; this contrasts with a nearly quantitative yield of a dibromodibenzotetra-azapentalene.² Each of the triazapentalene inner salts (IIa—c) and (VII) exhibited an aromatic one-proton triplet in its n.m.r. spectrum at higher field than the other aromatic proton signals (above τ 3). This probably corresponds to the proton *para* to the non-bridgehead nitrogen atom, since this position would be expected from MO calculations³ to experience the greatest electron density. The n.m.r. spectrum of the bromo-derivative of (IIa) showed the

TABLE
Properties of the triazapentalenes (II) and (VII)

Compound	Yield (%)	M.p. (°C)	Found (%)			<i>M</i> ⁺	Formula	Required (%)			<i>M</i>
			C	H	N			C	H	N	
(IIa)	36	179—180	78.8	6.0	14.3	287.1419	C ₁₉ H ₁₇ N ₃	79.5	6.0	14.6	287.1428
(IIb)	31	214—215	71.1	5.2	12.9	321.1041	C ₁₉ H ₁₆ N ₃ ³⁵ Cl	71.0	5.0	13.0	321.1033
(IIc)	28	135—136				301.1577	C ₂₀ H ₁₉ N ₃				301.1579
(IIa) perchlorate	83	211—212 (decomp.)	58.9	4.6	11.0		C ₁₉ H ₁₈ N ₃ ClO ₄	58.85	4.7	10.85	
(VII)	37	190—191	71.9	6.4	15.5	267.1378	C ₁₆ H ₁₇ N ₃ O	71.4	6.4	15.2	267.1372
(VII) perchlorate	79	231—232 (decomp.)	51.9	5.0	11.3		C ₁₆ H ₁₈ N ₃ ClO ₅	52.25	4.95	11.4	
			τ (CDCl ₃)					ν (KBr)/cm ⁻¹			
(IIa)			2.45 (8H, m), 7.10 (4H, m), 8.10 (4H, m), 3.28 (1H, t)					1498, 1470, 1440, 1428, 1362, 1306,			
(IIa) (CF ₃ ·CO ₂ H)			2.25 (9H, m), 7.00 (4H, m), 7.86 (4H, m)					1290, 1198, 1134, 878, 733			
(IIb)			2.42 (5H, s), 2.58 (2H, m), 3.18 (1H, t), 7.05 (4H, m), 8.02 (4H, m)					1500, 1475, 1423, 1370, 1310, 1291, 1100, 1090, 892, 719			
(IIc)			2.70 (7H, m), 3.24 (1H, t), 6.97 (2H, t), 7.40 (2H, m), 7.82 (3H, s), 8.10 (4H, m)					1500, 1472, 1445, 1365, 1265, 800, 740, 730			
(IIa) perchlorate [(CD ₃) ₂ CO]			2.20 (9H, m), 6.90 (2H, t), 7.21 (2H, t)					3070, 2980, 2350, 1480, 1115, 766, 742, 700			
(VII)			2.50 (3H, m), 3.02 (1H, t), 6.79 (2H, d), 7.18 (3H, s), 7.43 (2H, d), 8.74 (6H, s)					1673, 1514, 1480, 1386, 1356, 1272, 731			
(VII) (CF ₃ ·CO ₂ H)			2.28 (4H, m), 6.55 (2H, s), 6.98 (3H, s), 7.10 (2H, s), 8.58 (6H, s)								
(VII) perchlorate [(CD ₃) ₂ CO]			1.84 (1H, d, <i>J</i> 4 Hz), 2.33 (3H, m), 6.57 (2H, s), 7.12 (3H, s), 7.37 (2H, s), 8.73 (6H, s)					3300, 3080, 2970, 1690, 1570, 1495, 1250, 1100, 770, 750, 738			

of (IIa) perchlorate showed two discrete two-proton triplets, indicating that no hydrogen had been incorporated at *C*-4a. That of (VII) perchlorate exhibited a three-proton singlet at τ 7.12 between the methylene peaks at τ 6.57 and 7.37, indicating that protonation had not occurred at *C*-7. These results are again in contrast to the behaviour¹ of the dibenzotriazapentalene salts.

The overall reactivity of compounds (II) and (VII) appears to be less than that of the dibenzotriazapentalenes and also of mono- and di-benzotetra-azapental-

enes. expected signals for eight aromatic protons as a seven-proton singlet at τ 2.45 and a one-proton doublet at τ 2.71 (*J* 10 Hz), but lacked a high-field aromatic proton signal. Bromination had thus occurred at the activated 9-position, the doublet arising from proton at the other activated position (7), coupled with the proton at *C*-8.

¹ O. Tsuge and H. Samura, *Chemistry Letters*, 1973, 175.

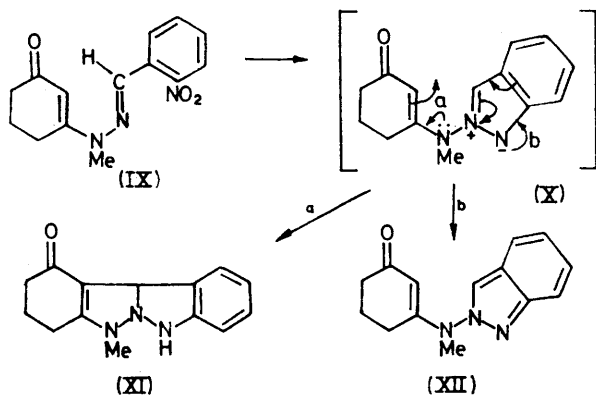
² R. A. Carboni, J. C. Kauer, W. R. Hatchard, and R. J. Harder, *J. Amer. Chem. Soc.*, 1967, **89**, 2626.

³ O. Tsuge and H. Samura, *Tetrahedron Letters*, 1973, 597.

Carboni and his co-workers² found that *v*-triazolo[2,1-*a*]benzotriazolium hydroxide inner salt (a monobenzotetra-azapentalene) gave a stable methiodide, although the methiodides of the dibenzotetra-azapentalenes were unstable. However, compound (IIa) did not react with methyl iodide during 3 days under reflux.

Compound (IIa) was unaffected by treatment with sodium borohydride in methanol and with lithium aluminium hydride in ether. Surprisingly, the ketone (VII) was also unchanged when treated with an excess of lithium aluminium hydride in ether. However, it reacted with hydroxylamine to give a good yield of the 8-oxime.

The greater resistance of compounds (II) and (VII) to electrophilic attack may be due to a preference for retaining the 10 π -electron shell of the triazapentalene nucleus. In the case of the dibenzotriazapentalene system, protonation at C-7, although destroying the 10 π system, results in a molecule in which conjugation between the benzene ring and the triazine system is still possible; this is not the case with the corresponding protonated monobenzotriazapentalenes.



The reaction of 3-[1-methyl-2-(*o*-nitrobenzylidene)hydrazino]cyclohex-2-enone (IX) with triethyl phosphite was investigated. It was envisaged that initial formation of the charge-separated indazole (X) would occur; this could cyclise to the tetracyclic compound (XI), or could rearrange to the 2-substituted indazole (XII). The mass spectrum of the oil obtained ($C_{14}H_{15}N_3O$) showed loss of 94 (C_6H_6O) and 29 (NCH_3) mass units. N.m.r. and i.r. data (see Experimental section) eliminated the tetracyclic structure and agreed with structure (XII).

EXPERIMENTAL

I.r. spectra were measured for potassium bromide discs. 1H N.m.r. spectra were measured for solutions in [2H]chloroform (unless otherwise stated) at 60 MHz, with tetramethylsilane as internal standard. Mass spectral determinations were performed by the Physico-chemical Measurement Unit, Harwell. The alumina for column chromatography was neutral, of activity I. Petroleum had b.p. 60–80°.

*Reactions of 3-Aryl-4,5,6,7-tetrahydro-2-(*o*-nitrophenyl)indazoles (I) with Triethyl Phosphite.*—The indazole⁴ (I) was heated in an excess of triethyl phosphite at 160° for 12 h with a slow stream of nitrogen passing through the solution. The solution was distilled under high vacuum to remove the excess of triethyl phosphite and the triethyl phosphate formed during the reaction. The residue was taken up in benzene and applied to an alumina column in petroleum. Gradient elution with petroleum–benzene (0–100%) liberated the 12-aryl-1,2,3,4-tetrahydro-6H-indazolo[2,1-*a*]benzotriazolium hydroxide inner salts (II) as yellow crystals (see Table).

*Reaction of 6,7-Dihydro-3,6,6-trimethyl-1-(*o*-nitrophenyl)indazol-4(5H)-one (VI) with Triethyl Phosphite.*—The indazole⁴ (VI) was treated as above and the product was worked up similarly; alternatively the indazole was refluxed with an excess of triethyl phosphite in xylene solution for 12 h. In this case the cold solution was treated with petroleum; on cooling 8,9,10,11-tetrahydro-7,10,10-trimethyl-8-oxo-5H-indazolo[1,2-*a*]benzotriazolium hydroxide inner salt (VII) separated and was filtered off (see Table). The oxime, obtained in 86% yield, had m.p. 223–224° (decomp.) (from acetone); ν_{max} 3200, 1610, 1550, 1505, 1468, 1352, 1276, 936, and 723 cm^{-1} (Found: C, 67.4; H, 6.5; N, 19.3. $C_{16}H_{18}N_4O$ requires C, 68.0; H, 6.4; N, 19.8%).

*Bromination of the Indazolo[2,1-*a*]benzotriazolium Hydroxide Inner Salt (IIa).*—To a solution of compound (IIa) (200 mg) in acetic acid, an excess of bromine in acetic acid was added. A red solid separated immediately. The mixture was added to water and extracted with chloroform. The extract was washed with aqueous sodium hydroxide (10%) then dried (K_2CO_3) and evaporated to yield a red gum. This was applied to an alumina column in petroleum. Elution with petroleum–benzene (1 : 1 v/v) liberated the yellow 9-bromo-derivative (21 mg), m.p. 192–193°, ν_{max} 1570, 1490, 1480, 1455, 1290, 769, 716, and 705 cm^{-1} , τ (100 MHz) 2.45 (7H, s), 2.71 (1H, d, *J* 10 Hz), 6.97 (2H, t), 7.23 (2H, t), and 8.10 (4H, m) (Found: C, 62.6; H, 4.3; N, 11.0%; M^+ , 365.0000. $C_{15}H_{16}BrN_3$ requires C, 62.3; H, 4.4; N, 11.5%; M , 364.9714). The mass spectrum showed an additional peak at *m/e* 442.9642 ($C_{15}H_{15}N_3Br_2$ requires 442.9634), indicating a trace of dibromo-compound.

*Reaction of 3-[1-Methyl-2-(*o*-nitrobenzylidene)hydrazino]cyclohex-2-enone (IX) with Triethyl Phosphite.*—Compound (IX)⁴ (0.5 g) was refluxed in an excess of triethyl phosphite (10 ml) at 160° for 12 h with a slow stream of nitrogen passing through the solution. The excess of solvent was distilled off under high vacuum and the residual brown oil applied to an alumina column in petroleum. Benzene eluted 3-[*N*-methyl(indazol-2-yl)amino]cyclohex-2-enone (XII) as a brown oil (0.362 g) (82%), ν_{max} 1635, 1585, 1382, 1248, and 751 cm^{-1} (N–H absent), τ 1.89 (1H, s), 2.50 (5H, m), 4.64 (1H, s), 6.52 (3H, s), and 7.80 (6H, m) (Found: M^+ , 241.1222. $C_{14}H_{15}N_3O$ requires M , 241.1215).

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⁴ A. J. Nunn and F. J. Rowell, unpublished work.