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We describe in this communication the synthesis and mass spectrometry of some 1-aryl-2-phenyl-4-oxo-4,5,6,7-tetrahydroindole (IIb, IVab-VIIIab, VIIIb, IXb) and 2-phenyl-4-oxo-4,5,6,7-tetrahydrobenzofuran derivatives (IIab). The fragmentations of these compounds are characterized by selectivity and the absence of any primary fragmentations involving substituents of the aryl rings. It is suggested that positive charges of the molecular ions of compounds II-IX are localized in the region of the carbonyl group and the conjugated double bond of the heterocycle.

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The biological activities of the 4-amino and 4-oxo derivatives of indole and furan have been reported by different groups of researchers (1,2). One of the methods of synthesis of these compounds consists of aromatization of the 4-oxo-4,5,6,7-tetrahydro derivative or of the corresponding oxime (3-5). However, the number of products prepared in these series is very limited. We report here the synthesis and mass spectrometry of some 1-aryl-2-phenyl-4-oxo-4,5,6,7-tetrahydroindole (IIb, IVab-VIIab, VIIIb, IXb) and 2-phenyl-4-oxo-4,5,6,7-tetrahydrobenzofuran (IIab) derivatives.

The starting materials for the syntheses, Ia and Ib, have been prepared by alkylation of 1,3-cyclohexanedione and dimedone respectively, with phenacyl bromide in the presence of anhydrous potassium carbonate (6). Treatment of Ia and Ib with concentrated sulfuric acid gave the corresponding benzofuran derivatives IIa and IIb. Upon

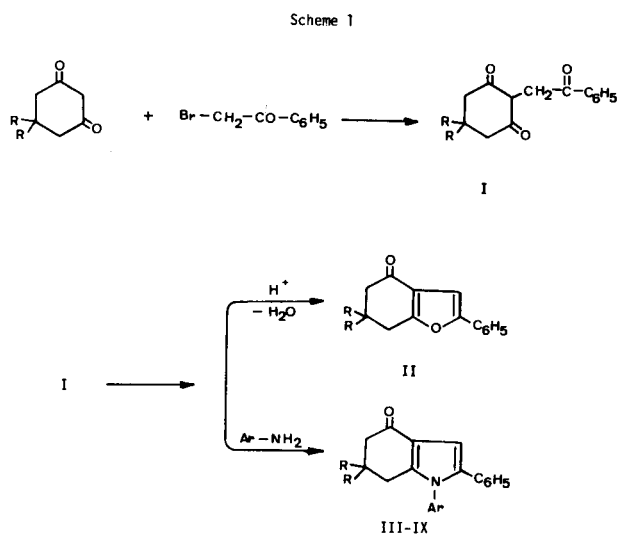
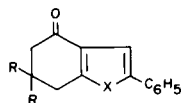


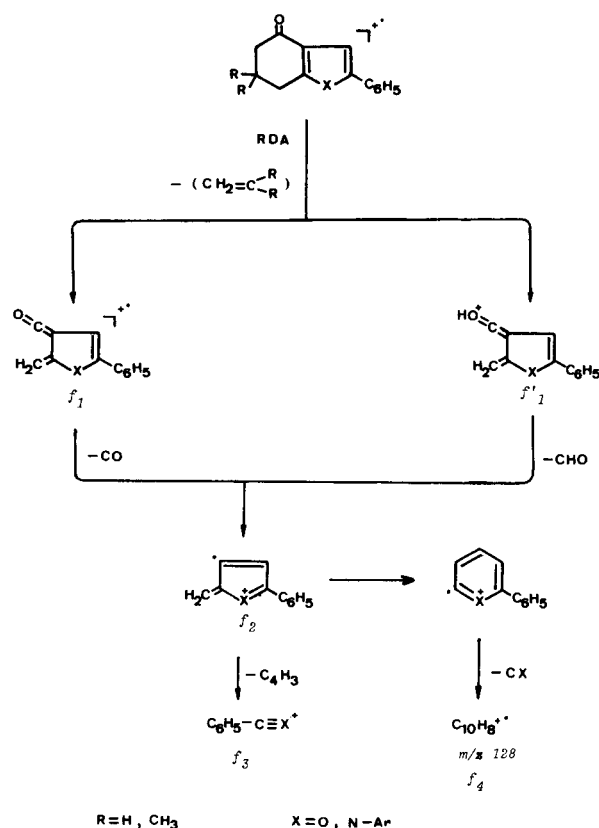
Table 1



Compound	R	X	mp °C	Yield %	Molecular formula	Elemental Analyses	
						Calcd. (Found)	H
IIa	H	O	132-133 (a)	80			
IIIb	CH <sub>3</sub>	O	103-105	100	C <sub>16</sub> H <sub>16</sub> O <sub>2</sub>	80.0 (79.8)	6.7 (6.9)
IIIb	CH <sub>3</sub>	C <sub>6</sub> H <sub>5</sub> -N	208 (b)	90			
IVa	H	2-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> -N	210-213	73	C <sub>21</sub> H <sub>19</sub> NO	83.7 (83.5)	6.4 (6.7)
IVb	CH <sub>3</sub>	2-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> -N	174-176	61	C <sub>23</sub> H <sub>23</sub> NO	83.9 (83.8)	7.0 (7.2)
Va	H	3-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> -N	187-190	75	C <sub>21</sub> H <sub>19</sub> NO	83.7 (83.4)	6.4 (6.5)
Vb	CH <sub>3</sub>	3-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> -N	184-185	72	C <sub>23</sub> H <sub>23</sub> NO	83.9 (83.8)	7.0 (6.8)
VIa	H	4-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> -N	226-227	79	D <sub>21</sub> H <sub>19</sub> NO	83.7 (83.6)	6.4 (6.6)
VIb	CH <sub>3</sub>	4-CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub> -N	184-187	70	C <sub>23</sub> H <sub>23</sub> NO	83.9 (83.8)	7.0 (7.3)
VIIa	H	4-BrC <sub>6</sub> H <sub>4</sub> -N	197-198	71	C <sub>20</sub> H <sub>16</sub> BrNO	65.6 (65.8)	4.4 (4.8)
VIIb	CH <sub>3</sub>	4-BrC <sub>6</sub> H <sub>4</sub> -N	180-185	66	C <sub>22</sub> H <sub>20</sub> BrNO	67.0 (67.1)	5.1 (5.0)
VIIIb	CH <sub>3</sub>	4-CH <sub>3</sub> OC <sub>6</sub> H <sub>4</sub> -N	181-182	76	C <sub>23</sub> H <sub>23</sub> NO <sub>2</sub>	80.0 (79.7)	6.7 (6.5)
IXb	CH <sub>3</sub>	3-O <sub>2</sub> NC <sub>6</sub> H <sub>4</sub> -N	188	74	C <sub>22</sub> H <sub>20</sub> N <sub>2</sub> O <sub>3</sub>	73.3 (73.5)	5.6 (5.4)

(a) Literature mp, 133.5° (11); (b) Literature mp, 205° (6).

Scheme 2



heating to the reflux temperature a mixture of I (a,b) and of the appropriate aromatic amine in acetic acid, the indole derivatives III-IX were obtained. Yields, melting points and elemental analyses are reported in Table 1. Spectral data (uv, ir, ms) are also given in Table 2.

### Discussion of Spectral Data.

#### a) UV Spectra.

The absorption band (P → π\*) of all the tetrahydrobenzofuran derivatives falls in the region 283-286 nm. On going from the tetrahydrobenzofuran to the tetrahydroindole series the absorption band is shifted toward short wave length (250-256 nm). Of all the *N*-aryl substituted tetrahydroindole derivatives only that with the *ortho*-tolyl substituent, IV (a,b), shows two absorption bands of similar intensities at 250 and 279 nm. The long wave absorption (279 nm) arises as a consequence of the presence of the *ortho*-tolyl and pyrrole rings in two different planes. The coplanarity of these two rings is prohibited due to the steric interaction of the methyl group of the *ortho*-tolyl substituent with the tetrahydroindole moiety.

#### b) IR Spectra.

The higher stretching vibration of the carbonyl group (ν CO) of the tetrahydrobenzofuran derivatives compared with their indole analogues (Table 2) is attributed to the stronger electron donating character of the pyrrole ring.

Table 2  
UV, IR and MS Data

Compound	UV	IR	Mass Spectra (b)
	λ max (log ε)	ν cm <sup>-1</sup>	M/Z (relative intensity)
IIa	283 (3.7)	1670 (a)	240 (62), 185 (31), 184 (88), 157 (10), 156 (75), 128 (13), 105 (100), 77 (28), 51 (9), 43 (4), 41 (8)
IIb	219 (4.7) 286 (4.5)	1665	
IIIb	253 (4.8)	1665 (a)	315 (100), 260 (30), 259 (75), 232 (21), 231 (91), 180 (40), 154 (10), 128 (10), 57 (13), 43 (13), 40 (35)
IVa	249 (4.4) 279 (4.3)	1660- 1640	301 (100), 258 (9), 245 (37), 244 (29), 230 (16), 194 (15), 115 (7), 91 (37), 77 (4), 65 (20), 51 (3)
IVb	250 (4.3) 279 (4.2)	1655- 1640	329 (100), 274 (24), 273 (43), 258 (39), 245 (79), 244 (50), 230 (34), 194 (28), 91 (43), 65 (20)
Va	256 (4.3)	1660- 1640	301 (100), 273 (12), 245 (45), 244 (32), 230 (14), 194 (25), 185 (14), 141 (14), 129 (59), 128 (18), 91 (70)
Vb	255 (4.5)	1660- 1645	329 (100), 274 (22), 273 (60), 258 (35), 245 (87), 244 (53), 230 (29), 194 (31), 152 (11), 91 (40), 65 (23)
VIa	253 (4.3)	1645	301 (100), 273 (29), 272 (12), 245 (62), 244 (46), 230 (28), 194 (17), 115 (12), 91 (38), 65 (15), 51 (13)
VIb	253 (4.5)	1645	329 (100), 274 (25), 273 (65), 246 (50), 245 (75), 244 (80), 194 (25), 136 (14), 90 (45), 64 (25), 50 (4)
VIIa	256 (4.5)	1660- 1650	367 (50), 365 (49), 339 (26), 337 (26), 311 (7), 309 (7), 360 (22), 258 (22), 230 (100), 157 (16), 155 (16), 152 (12)
VIIb	253 (4.5)	1660- 1650	395 (27), 393 (26), 339 (16), 337 (16), 311 (6), 309 (6), 260 (8), 258 (9), 230 (100), 157 (8), 155 (8), 152 (7)
VIIIb	254 (4.5)	1660- 1640	345 (100), 290 (15), 289 (41), 261 (70), 246 (47), 230 (17), 210 (32), 144 (12), 92 (10), 77 (22), 65 (11)
IXb	253 (4.5)	1660- 1650	360 (100), 305 (70), 304 (67), 277 (12), 276 (42), 229 (9), 228 (9), 225 (15), 204 (15), 179 (15), 76 (13)

(a) Measured in nujol; (b) Reported are the molecular ion and the 10 most abundant fragment ions.

Table 3

Per Cent of Total Ion Intensities ( $\Sigma_{3,1}$ ) for Characteristic Ions in the Mass Spectra of Compounds II-IX

Compound	M*	F <sub>1</sub>	F <sub>1</sub> '	F <sub>2</sub>	F <sub>3</sub>	F <sub>4</sub>
IIb	13.0	15.0	5.4	12.9	17.2	2.1
IIIb	14.9	8.3	3.3	10.0	4.4	1.1
IVa	17.5	0.6		6.4	2.6	0.4
IVb	15.1	4.7	2.6	8.7	2.4	1.0
Va	12.3	1.3		4.7	2.4	1.4
Vb	15.4	6.7	2.5	9.7	3.4	0.6
VIa	14.2	3.0		6.5	1.8	0.7
VIb	14.7	6.7	2.4	7.8	2.7	0.2
VIIa	15.1	4.5		1.0	1.4	0.3
VIIb	14.7	7.6	1.1	2.9	3.8	0.1
VIIIb	20.6	8.3	3.1	14.4	6.6	0.7
IXb	16.5	11.0	11.5	6.9	2.4	1.2

### c) MS Spectra.

The molecular ions of the compounds investigated have very similar stabilities (12-21% of total ion intensities) independent of the nature of the heterocycle or the electronic properties of the substituent. In both series (X = O and X = N) the molecular ion suffers Retro Diels-Alder (RDA) fragmentation. If the six membered ring is substituted (R = CH<sub>3</sub>) ion f<sub>2</sub>' resulting from the transfer of a hydrogen atom is obtained in addition to ion f<sub>1</sub>. Further fragmentations produce ions f<sub>2</sub>, f<sub>3</sub> and f<sub>4</sub>. Plausible fragmentation pathways are shown in Scheme 2.

It is noteworthy that ions (M-H) which characterize the fragmentation of aryl indole (7-9) are practically absent from the mass spectra of compounds III-IX. Fragmentations of the molecular ion due to the presence of substituents in the aryl ring and giving rise to ions (M-NO<sub>2</sub>), (M-NO) (compound IXb) and to ions (M-CH<sub>2</sub>O) (compound VIIIb) are not observed. The results of this investigation indicates that the positive charge of the molecular ions of compounds II-IX is localized in the region of the carbonyl group and of the conjugated double bond of the heterocycle.

## EXPERIMENTAL

Unless otherwise specified uv and ir spectra were measured in ethanol and chloroform solutions respectively with Perkin-Elmer 282 and 472 spectrophotometers. The mass spectra were recorded with a Varian Mat 112S spectrometer using a solid samples probe. Melting points are not corrected and were determined with a Reichart Thermovar instrument.

Triketones Ia and Ib were prepared by the procedure of Stetter (11) with yields of 50% and 80%, respectively.

### Preparation of Tetrahydrobenzofuran Derivatives. General Procedure.

Compound I (a,b) (0.14 mole) was treated with 50 ml of concentrated sulfuric acid at room temperature for 30 minutes. The usual workup gave the 2-phenyl-4-oxo-4,5,6,7-tetrahydrobenzofuran derivatives II (a,b).

### Preparation of Tetrahydroindole Derivatives. General Procedure.

These derivatives (III-IX) were prepared according to the method of Stetter (6) by heating at 130-150° for 1-2 hours an equimolar mixture of I (a,b) and an aromatic amine in acetic acid.

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