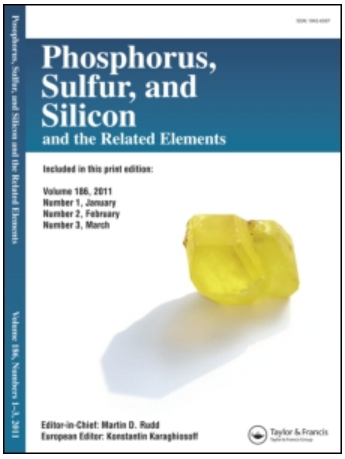

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ORGANOPHOSPHORUS CHEMISTRY, 27[1]. THE REACTION OF ISATIN, 5-METHYLISATIN AND THEIR MONOXIMES WITH ALKYL PHOSPHITES, TRIPHENYLPHOSPHINE AND PHOSPHORUS YLIDES

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5-Methylisatin (**1b**) reacts with TAP (**4a–c**) and/or DAP (**3a–c**) to give the respective dialkyl α-hydroxyphosphonates (**8a–c**). Isatin-monoxime (**5a**) and 5-methyl isatin-monoxime (**5b**) react with alkyl phosphites to give dialkyl 2-oxo-indolyl phosphonates (**8a–c, 12a–f, 15a–c**) as major products. The carbonyl-group at position −3 in **1b** is deoxygenated by triphenylphosphine to give a new phosphorus ylide (**17**) and by methylenetriphenylphosphoranes (Wittig-reagents, **7a–c**) to afford the respective 3- substituted methylenes (**19a–c**) in good yields. Possible reaction mechanisms were considered and structural assignments were based upon analytical, chemical and spectroscopic (IR, ^{1}H NMR, ^{31}P NMR and MS) results.

Key words: Isatins, isatinmonoximes, phosphorylation, triphenylphosphine, Wittig-reaction.

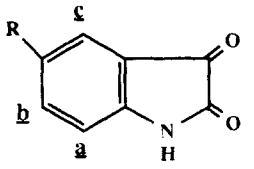
INTRODUCTION

Considerable attention has been paid to studying the reaction of isatin (**1a**)[2–4] and isatin-monoimines (**2**)[5] with dialkyl phosphites (DAP, **3**) and trialkyl phosphites (TAP, **4**). To the best of our knowledge, however, there is no information in the literature regarding the behaviour of isatin monoximes toward the same reagents. This encouraged the investigation of the reaction of isatin monoxime (**5a**) and 5-methylisatin monoxime (**5b**) with DAP and TAP. In response to our growing interest in the organophosphorus chemistry of carbonyl compounds[6–9] the reaction of 5-methylisatin (**1b**) with triphenylphosphine (TPP, **6**) and methylene triphenylphosphoranes (Wittig-reagents, **7a–c**), was also explored.

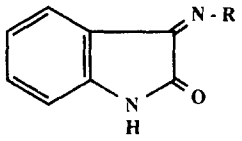
RESULTS AND DISCUSSION

The reaction of 5-methylisatin (**1b**) with TAP (**4a–c**) in absence of solvent at ambient temperature proceeded only in the presence of a protonating agent (H_2O

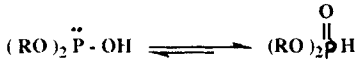
†Dedicated to Professor Dr. M. M. Sidky on the occasion of his 65th birthday.



1a, R = H
b, R = CH_3



2, R = alkyl and /or aryl



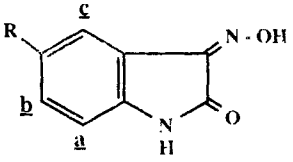
DAP, 3

$(RO)_3$ P:

TAP, 4

3a, R = CH_3, DMP
b, R = C_2H_5, DEP
c, R = C_3H_7-i, DiPP

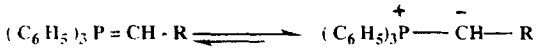
4a, R = CH_3, TMP
b, R = C_2H_5, TEP
c, R = C_3H_7-i, TiPP



5a, R = H
b, R = CH_3

$(C_6H_5)_3$ P:

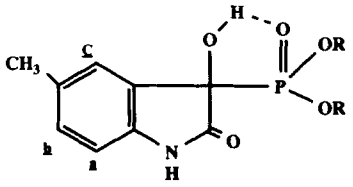
TPP, 6



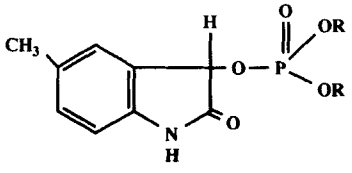
7 a, R = $COOCH_3$
b, R = $COOC_2H_5$
c, R = COC_6H_5

SCHEME 1

or CH_3COOH) to give colorless crystalline products. They were assigned the dialkyl α-hydroxyphosphonate structures **8a–c**, respectively since they showed positive chemical shifts[10] (vs. 85% H_3PO_4) around δ = 16.00 ppm in their ^{31}P NMR spectra. On this basis, an alternative dialkyl phosphate structure (cf. 9) for 1b-TAP products can be excluded.‡ The same compounds (**8a–c**) were respectively obtained by

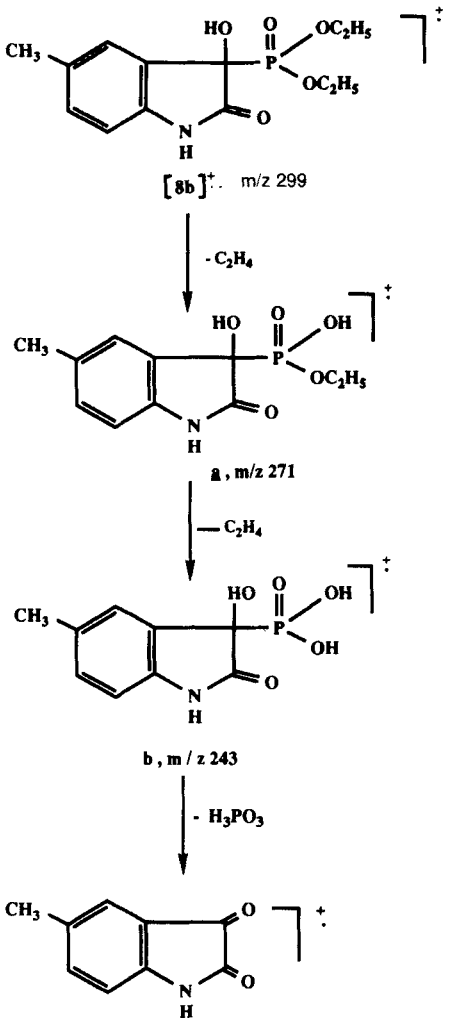


8a, R = CH_3
b, R = C_2H_5
c, R = C_3H_7-i



9 (R as in 8)

‡cf. Structures 8 and 9.



SCHEME 2

allowing **1b** to react with DAP (**3a–c**) in absence of solvent at 100°C. Elementary and molecular weight determination (MS) for compound **8b**, for example, corresponded to $C_{13}H_{18}NO_5P$. Its IR spectrum (in KBr, cm^{-1}) disclosed the presence of sharp absorption bands at 1230 (P=O, bonded) and 1030 (P—O—C_2H_5).[11] The strong aryl-carbonyl band present in the IR-spectrum of **1b** at 1745 was absent in the spectrum **8b**. However, an absorption band appeared at 1715 (amide-carbonyl absorption). The ^1H NMR spectrum of **8b** (in $CDCl_3$, δ ppm scale) showed protons of the ethoxy-CH_3 groups as two triplets at 0.95 (3H) and 1.1 (3H), while the ethoxy-CH_2 protons of the same groups appeared as two quintets at 3.8 (2H) and 4.00 (2H). Protons of the aryl-CH_3 group (3H) gave a singlet at 2.05 while signals due to the aromatic protons (3H) were shown at 6.5 (Ha, d), 6.75 (Hb, d) and

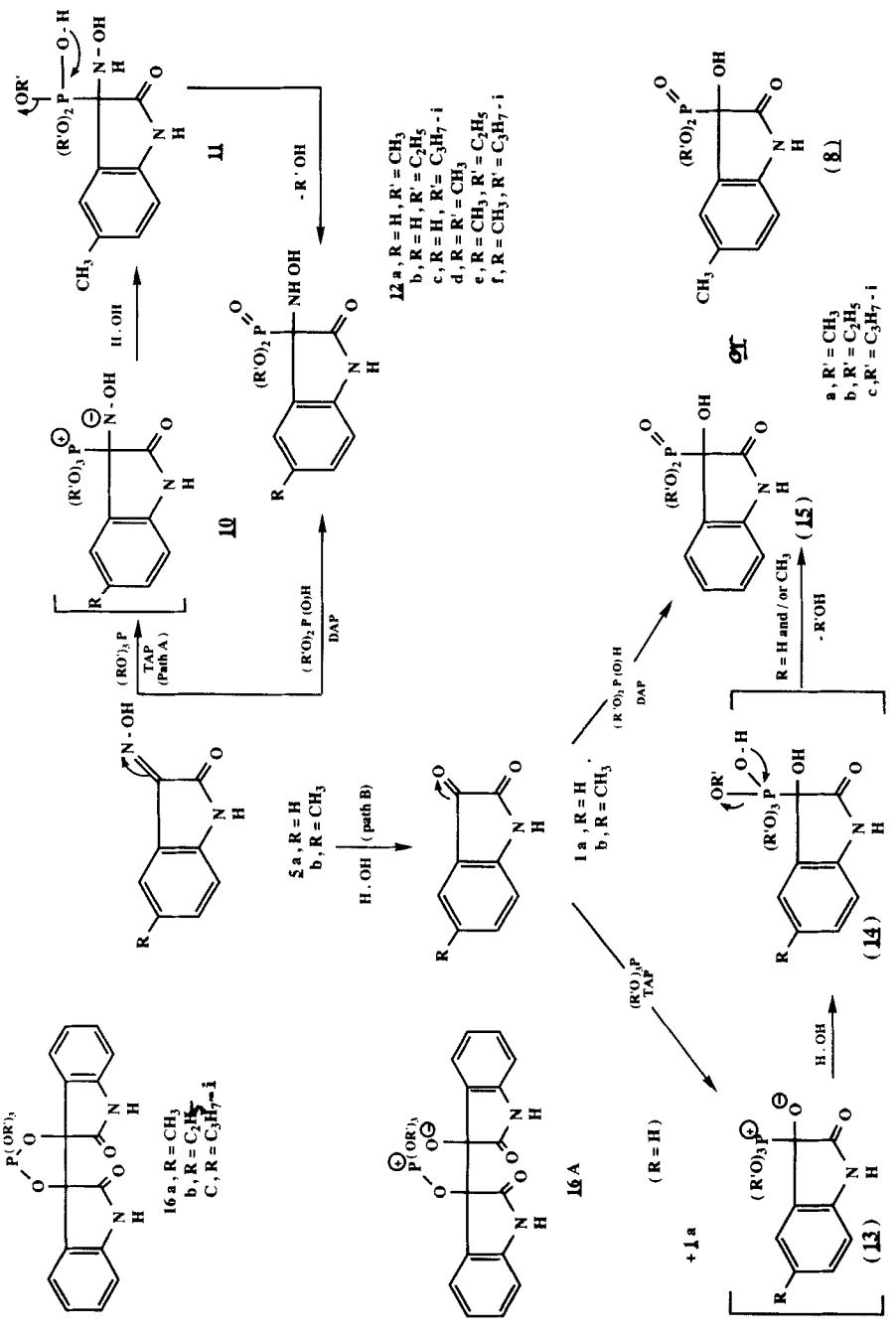
7.05 (Hc, s). D_2O-exchangeable protons were also recorded in the spectrum of **8b** at 5.00 (OH) and 9.65 ppm (NH).

The ^{13}C NMR spectrum of **8b** was also in accord with the proposed structure (cf. Experimental). The mass spectrum of **8b** showed the molecular ion peak at m/z 299 (M^+, $C_{13}H_{18}NO_5P$, 48%). Successive loss of two C_2H_4 molecules from M^+ afforded the radical cations at m/z 271 (30%) and at m/z 243 (100%). The base peak then ejects an H_3PO_3 molecule to afford the ion peak at m/z 161 (72%) which corresponds to the radical cation of 5-methylisatin (**1b**) itself. It is notable that the behavior of **8b** under electron impact simulates its behavior upon thermolysis under reduced pressure which produces 5-methylisatin (**1b**) along with diethyl phosphite (DEP, **3b**) (cf. Experimental) according to:

$$\underline{8}\mathbf{b} \xrightarrow[5\ \text{mm/Hg}]{\Delta,\ 230^\circ\text{C}/} \underline{1}\mathbf{b} + \text{DEP}\ (\underline{3}\mathbf{b})$$

Trimethylphosphite (TMP, **4a**) reacts with isatin-monoxime (**5a**) in the absence of solvent at 100° to give a colorless crystalline product (yield: 55%) which was formulated as dimethyl 3-(hydroxyamino)-2-oxo-1H-indol-3-yl) phosphonate (**12a**). Isatin (>5%) and dimethyl (3-hydroxy-2-oxo-1H-indol-3-yl) phosphonate (**15a**), 10%) were also isolated in the same reaction. The identity of **15a** was established by direct comparison of its m.ps and IR spectrum with those of a reference specimen prepared by reacting **1a** with DMP (**3a**).[2]

The assigned dialkyl α-hydroxyaminophosphonate structure **12** was supported by the following: (a) The ^{31}P NMR measurement (in DMSO-d_6) for **12a** showed a positive chemical shift (vs. 85% H_3PO_4) at δ = 17.00 ppm which coincides with a phosphonate structure.[4,10] (b) Its IR spectrum (in KBr) revealed the characteristic absorption bands attributable to the stretching frequencies of OH (3450 cm^{-1}) and NH (3230 cm^{-1}) functions. Besides, it exhibited intense bands corresponding to the $\diagdown\!\!\diagup$P=O and P—O—C (methyl) stretching vibrations,[11] at 1230 cm^{-1} and 1010 cm^{-1}, respectively. (b) Moreover, compound **12a** could be unequivocally prepared by reacting isatin-monoxime (**5a**) with DMP in absence of solvent at 100°C. In the latter reaction, isatin (**1a**) and **15a** were also isolated and identified (Experimental). When subjected to thermolysis under reduced pressure compound **12a** regenerated **5a** and DMP as expected.[4,12] Formation of compounds **12a** (55%) and **15a** (10%) in the reaction of **5a** with TMP is markedly accelerated when controlled amounts of a protonating agent (H_2O or CH_3COOH) were present in the reaction medium. Scheme 3 compiles the reaction courses of isatin monoxime (**5a**) and 5-methyl isatin-monoxime (**5b**) with DAP (**3a–c**) and TAP (**4a–c**) to give the observed products. It also shows formation of compounds **8**, **12** and **15** through reacting (**5a, b**) with TAP (**4a–c**). This involves primary nucleophilic attack by the phosphite-phosphorus of TAP on the oxime-carbon atom of **5** to give the *C*-phosphonium betaine **10** (path *A*). The dipolar structure **10** can add elements of water (unavoidable moisture) as do many phosphobetaine structures[13–15] to give intermediate **11** with pentavalent phosphorus. The latter decomposes *via* expulsion of R'OH to give compounds **12a–f**. Formation of compounds **15** and **8** is best explained in terms of partial hydrolysis of monoximes **5a, b** (path **B**) to afford their respective



SCHEME 3

TABLE I

Compound	Yield in %	m.p. °C (Solvent)	Mol. Form (M. wt)	Anal. (Calcd./Found) C	H	N	p	M⁺ m/z	IR cm⁻¹ —OH	—NH	P=O	P—O—C (Alkyl)
8a	80	190	$C_{11}H_{14}NO_5P$	48.71	5.20	5.16	11.42		3320	3110	1230	1050
		(a)	(271.20)	48.54	5.18	5.12	11.31					
8b	80	184	$C_{13}H_{18}NO_5P$	52.17	6.06	4.68	10.35	299	3400	3180	1240	1050
		(b)	(299.26)	51.95	6.04	4.42	10.23					
8c	85	162	$C_{15}H_{22}NO_5P$	55.04	6.77	4.27	9.46		3420	3150	1200	1000
		(c)	(327.31)	55.02	6.45	3.98	9.24					
12a[g]	80	105	$C_{10}H_{13}N_2O_5P$	44.12	4.81	10.29	11.37	272	3440	3230	1150	1030
		(d)	(272.19)	44.04	4.53	10.12	11.22					
12b[g]	85	156	$C_{12}H_{17}N_2O_5P$	48.00	5.70	9.33	10.31		3420	3030	1200	1000
		(e)	(300.25)	47.95	5.42	9.11	9.98					
12c[g]	88	182	$C_{14}H_{21}N_2O_5P$	51.21	6.44	8.53	9.43		3440	3100	1250	1030
		(f)	(328.30)	51.09	6.11	8.35	9.26					
12d[g]	85	114	$C_{11}H_{15}N_2O_5P$	46.16	5.28	9.78	10.82		3400	3200	1250	1030
		(c)	(286.22)	45.99	5.50	9.44	10.68					
12e[g]	90	149	$C_{13}H_{19}N_2O_5P$	49.68	6.09	8.91	9.85	314	3350	3200	1200	1000
		(d)	(314.27)	49.28	6.04	8.53	9.35					
12f[g]	95	134	$C_{15}H_{23}N_2O_5P$	52.62	6.77	8.18	9.04		3400	3150	1250	1050
		(e)	(342.32)	52.49	6.55	8.22	9.33					
									(—NH)	(CO, ester)		(CO, amide)
19a	80	209	$C_{12}H_{11}NO_3$	66.35	5.10	6.44	—	217	3200	1730		1660
		(b)	(217.22)	65.99	4.90	6.32						
19b	85	173	$C_{13}H_{13}NO_3$	67.52	5.66	6.05	—	231	3150	1720		1610
		(a)	(231.25)	67.33	5.58	5.97						
19c	75	179	$C_{17}H_{13}NO_2$	77.55	4.97	5.31	—		3200	1720		1650
		(c)	(263.29)	77.23	5.14	5.40						

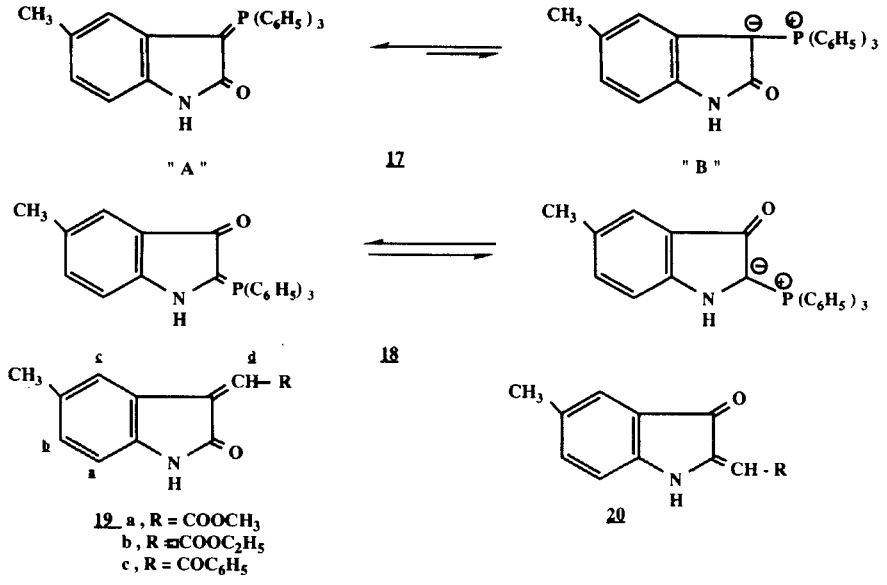
Solv. of cryst. (a) light petroleum, (b) cyclohexane, (c) ether, (d) chloroform, (e) acetone, (f) ethanol/ether and (g) yields are based on the reaction of **5a, b** with the appropriate DAP (**3a–c**) and they are approximated.

isatins (**1a, b**). Addition of TAP to (**1a, b**) produces the *C*-phosphonium betaine **13** which adds elements of water to produce intermediate **14** with penta-covalent phosphorus (in the case of both **1a** and **1b**) which yields compounds **8a–c** and/or **15a–c** *via* loss of R'OH. Apparently, the latter process is accelerated when a protonating agent (e.g. H_2O or CH_3COOH) is present. This does not give any chance for **13** to react with another molecule of **1** to give **16** (via **16** A)[2].

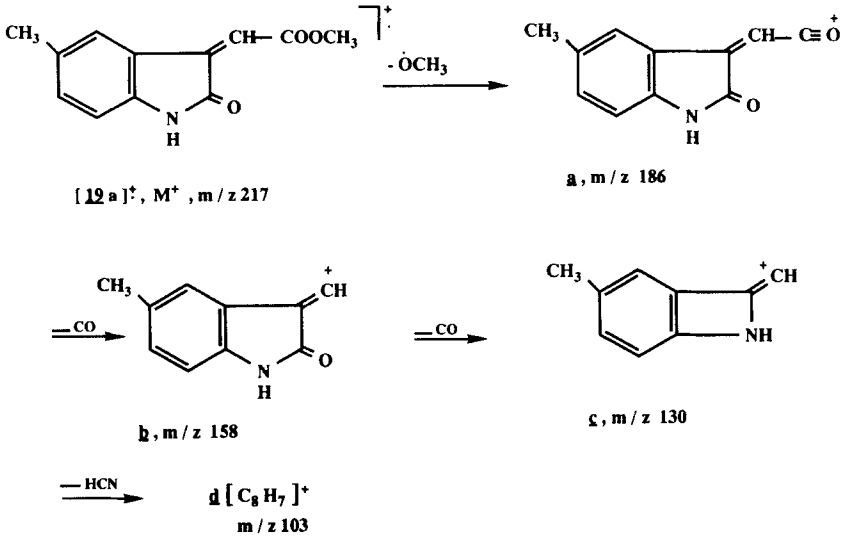
Analytical, physical and spectroscopic data of compounds **8–c** and **12a–f** are compiled in Table I.

When 5-methylisatin (**1b**) was allowed to react with triphenylphosphine (TPP, **6**) in a 1:2 molar ratio in dry toluene at reflux temperature, a colorless crystalline material was obtained for which the ylidenetriphenylphosphorane structure **17** was assigned. Triphenylphosphine oxide (TPPO) was also isolated and identified[16] in this reaction. Structural evidence for **17** were based upon the following: (a) correct elementary and molecular weight (MS) measurements corresponded to $C_{27}H_{22}NOP$, (b) its ^{31}PNMR spectrum (in DMSO d_6, vs 85% H_3PO_4): one signal at δ = 11.45 ppm which matches a structure incorporating a C=P group[10] (cf. **17A**).

The IR-spectrum of **17** (in KBr, cm^{-1}) exhibited absorption bands at 3255 (NH), 1680 (C=O, amide), 1620 (C=C, aromatic), 1320 (C=P)[11], 1480 and 1010 cm^{-1} [P—C—(aryl)].[11,17] Moreover, the aryl carbonyl band present in the IR spectrum of **1b** at 1745 cm^{-1} was absent in the spectrum of **17**. (d) A proton-ratio-value of 18:3 (aromatics: CH_3) was recorded in the ^{1}HNMR spectrum of **17** (in DMSO-d_6). (e) The mass spectrum of compound **17** showed the molecular ion peak at m/z 407 (M^+, $C_{27}H_{22}NOP$, 2.1%) which also matches the assigned ylidenetriphenylphosphorane structure. On the basis of the aforementioned analytical and spectral arguments, the other alternative structure **18** can be excluded from further consideration.



SCHEME 4



SCHEME 5

5-Methylisatin (**1b**) was found to react with carbmethoxymethylenetriphenylphosphorane (**7a**) in toluene at reflux temperature for 6 h, to give an orange-red crystalline product which is formulated as 3-carbmethoxymethylene-5-methyl-2-oxo-1H-indole (**19a**). Similarly, oxindoles **19b, c** were obtained by reacting **1b** with the phosphorus ylides **7b** and **7c**, respectively. In all these reactions, TPPO was isolated and identified.[16] Structure **19** was supported by the following evidences: (a) Compatible elementary and MS measurements were gained for all compounds. (b) The IR spectrum of **19a** (in KBr, cm^{-1}) showed strong absorption bands due to the ester —CO at 1730, due to the amide-carbonyl at 1660 and due to the C—O stretching vibration at 1330 cm^{-1}. Absorptions due to the same groups appeared at 1720, 1610 and 1290 cm^{-1}, respectively in the spectrum of **19b**. Moreover, the aryl-carbonyl group absorption found in the IR-spectrum of **1b** at 1745, *vide supra*, was absent in the spectra of **19a, b**. (c) The ^{1}HNMR spectrum of **19b** (in $CDCl_3$, δ ppm scale) showed signals at 1.40 (3H, carbethoxy-$\underline{CH_3}$, t), 2.15 (3H, aryl-$\underline{CH_3}$, s), 4.35 (2H, carbethoxy-$\underline{CH_2}$, q), 6.65 (Ar-H$\underline{a}$, d), 6.62 (Ar-H$\underline{c}$, s), 7.18 (Ar-H$\underline{b}$, d). 8.20 (NH, bs) and 8.20 (exocyclic CH$\underline{d}$ proton, s). Based upon these arguments, the alternative structure **20** can be overlooked.

The mass spectrum of **19a** showed the molecular ion peak at m/z 217 (M^+, $C_{12}H_{11}NO_3$, 75%). Loss of CH_3O radical from M^+ yields the cation at m/z 186 (40%) which can eject a neutral CO molecule to afford the ion peak at m/z 158 (100%). Loss of 28 mass units (CO) from the latter cation affords the ion at m/z 130 (60%) which, in turn, suffers loss of HCN molecule to give the cation at m/z 103 (30%). The latter process is observed in the majority of *N*-heterocycles.[11,18]

CONCLUSION

As a corollary to this work, new dialkyl phosphonate derivatives of types **8a–c**, and **12a–f** were prepared and characterized by reacting isatins **1a, b** and/or their

monoximes (**5a, b**) with alkyl phosphites. These new compounds bear structural functionalities to which many compounds used as biocides owe their activities.[19]

Although isatin (**1a**) is unreactive towards attack by TPP[2], 5-methylisatin (**1b**) reacts smoothly with the same reagent to give the new ylid-phosphorane **17**. This represents a new and simple route for preparing complex Wittig-Reagents derived from *N*-heterocycles which are of further synthetic use. Triphenylphosphine (TPP, **6**) and methylene triphenylphosphoranes **7a–c** attack isatins **1b** only at the carbonyl group at position −3. Apparently, this is attributed to the amidic[2] (inactive) nature of the carbonyl group at position −2 which explains also its non-involvement in many chemical interactions.[20]

EXPERIMENTAL

All melting points are uncorrected. The IR-spectra were run on a Perkin-Elmer Infracord Spectrometer Model 197 (Grating) in KBr. The ^{1}HNMR spectra and the ^{13}CNMR spectrum were measured on a Bruker Spectrometer Model WH-90 and the chemical shifts were recorded in δ-scale ppm relative to TMS. The ^{31}P NMR spectra were taken on a Varian CFT-20 (*vs.* 85% H_3PO_4). The mass spectra were performed at 70 eV on MS-50 kratos (A.E.I) Spectrometer provided with data system. Isatins **1a, b**, DAP (**3a–c**) and TAP (**4a–c**) were purchased from Aldrich Chem. Co., and purified before use. Monoximes **5a**,[21] and Wittig-reagents **7a**,[22] **7b**[22] and **7c**[23] were prepared according to known procedures. 5-Methylisatin monoxime **5b** was now prepared for the first time. Elemental analyses were carried out at the Microanalysis Laboratory, National Research Centre, Cairo.

Reaction of 5-Methylisatin (**1b**) *with Trialkyl phosphites* (**4a–c**), *in presence of protonating agents.*

General Procedure: A mixture of compound **1b** (0.5 g, 0.003 mol) and TAP (**4**, trimethyl, triethyl and/or triisopropyl phosphite) (0.01 mol) and acetic acid (or H_2O, 1 ml) was stirred in the absence of solvent. The reaction mixture was kept at room temperature for 8 h, then filtered and treated with petroleum ether (b.r. 40–60°).

The solid product so obtained was crystallized from the appropriate solvent to give compounds (**8a–c**) as colorless crystals (cf. Table I).

Reaction of 5-Methylisatin (**1b**) *with Dialkyl Phosphites* (**3a–c**).

General Procedure: A mixture of compound **1b** (0.5 g, 0.003 mol) and DAP (**3**, dimethyl, diethyl and/or diisopropyl phosphite) (0.01 mol) was heated at 100°C for 6 h. After removal of the volatile materials, *in a vacuo*, the solid product, so obtained, was collected (yield ca. 80%) and recrystallized from the appropriate solvent to give colorless crystals (**8a–c**) (m.p, mixed mps. and comparative IR spectra).

^{1}HNMR of **8a** (DMSO-d_6, δ-scale ppm): Signals at 2.25 (3H, s), Aryl-C$\underline{H}_3$. 3.6 (d, 3H) J_{HP} = 12 Hz, P—OCH, 3.75 (d, 3H) J_{HP} = 12 Hz, P—O—CH_3, 6.7 (Ha, d) J_{HH} = 8 Hz Ar-H$\underline{a}$ 7.05 (Hb, d) J_{HH} = 8 Hz (Ar-H$\underline{b}$, 7.2 (s, H$\underline{c}$) (Ar-H$\underline{c}$).

The ^{13}C MNR spectrum of **8b** (in DMSO d-6) showed signals at 177.4 (C-1, C-O), 22.2 (C-9, CH_3), 59.5 (C-2). 130.6 (C-3). 129.2 (C-4). 131.6 (C-5), 111.1 (C-7), 126.0 (C-6), 141.6 (C-8), 65.0, 65.1, (ethoxy-$\underline{C}H_2$) and 17.1 and 17.3 (ethoxy-$\underline{C}H_3$).

Action of Heat on **8b**: Compound **8b** (0.5 g) was heated in a cold finger sublimator at 230° (bath temperature) under reduced pressure (5 mm/Hg) for 30 minutes. The compound that sublimed was collected, recrystallized from ethylacetate to give red crystals, proved to be 5-methylisatin **1b** (identified by m.p., mixed mps. and comparative IR spectra). Diethylphosphite was detected in the receiver by the development of a violet color on addition of 3,5-dinitrobenzoic acid in the presence of alkali.[24]

Preparation of 5-Methylisatinmonoxime (**5b**). A mixture of **1b** (5 g; 0.03 mol) and hydroxyl aminhydrochloride (2.15 g) in absolute ethanol was stirred at ambient temperature for 1 h. The precipitated material was collected (4.9 g; 90%) and recrystallized from methanol to give **5b** as golden yellow needles. m.p. 250°C.

Analysis calcd. for	$C_9H_8N_2O_2$,		
	C,	H,	N,
	61.35	4.57	15.90
Found	C	H	N %
	61.25	4.35	15.50

IR (KBr, cm $^{-1}$): Bands at 3100 (NH), 3400 (OH), 1720 (C=O).
^{1}HNMR (DMSO, δ ppm): signals at 2.32 (3H, CH_3, s), 6.76 (1Hb, d, J_{HH} = 7.5 Hz), 7.08 (1Ha, d, J_{HH} = 7.5 Hz) and 7.84 (Hc, s) 13.20 (NH) 10.56 (OH)

Reaction of Isatin-monoxime (**5a**) *and 5-Methylisatinmonoxime* (**5b**) *with Trialkyl Phosphites* (**4a–c**), *in presence of protonating agents.*

General Procedure. A mixture of isatin monoxime **5a** (1 g, 0.006 mol) and trialkyl phosphites (trimethyl, triethyl and triisopropyl phosphites) (4 ml) was heated at 100°C for 12 h in the presence of acetic acid (or H_2O, 1 ml). After evaporation of the volatile materials, *in vacuo*, the residual substance was treated with ethanol (100 ml) and evaporated to dryness in the presence of silica gel (5 g). The mixture was then added to a column previously charged with silica gel in light petroleum (b.r. 40–60°C). The column was eluted with light petroleum followed by light petroleum containing increasing amounts of ethylacetate to give the following components in sequence:

1) Light petroleum-ethyl acetate (9:1) eluted a red substance mp. 202°C (>5%) proved to be isatin **1a** (mp, mixed mps., and comparative IR spectra). Yield >5%.

2) Light petroleum-ethylacetate (5:5) eluted a colorless substance that was recrystallized from the suitable solvent to give (**12a–c**) (55–65%). For mps, physical, and analytical data, see Table I.

3) Light petroleum-ethylacetate (3:7) eluted a colorless substance which corresponded and proved to be the respective phosphonate compound **15(a–c)**[2] (10–20%) (mp, mixed mps and comparative IR spectra).

Similarly, by allowing **5b** (1 g, 0.006 mol) and TAP (**4a–c**), (0.01 mol) to react in presence of 1 ml H_2O (or CH_3COOH), compounds **1b**, **8(a–c)** (15–25%) and **12(e–f)** (60%) were isolated and characterized (mp, mixed mp and comparative IR spectra) (cf. Table I).

Reaction of Isatin-monoxime (**5a**) *and 5-Methylisatinmonoxime* (**5b**) *with Dialkyl phosphites* (**3a–c**).

General Procedure: A mixture of istain-monoxime **5a** (1 g, 0.006) and DAP (dimethyl, diethyl and/or diisopropyl phosphite) (0.01 mol) was heated at 100°C for 18 h. After evaporation of the volatile materials, *in vacuo*, the residual substance was dissolved in ethanol (100 ml) and evaporated to dryness in the presence of silica gel (5 g). The adsorbed mixture was subjected to column chromatography as described previously. Elution with petroleum ether containing increasing amounts of ethylacetate gave the following compounds in sequence:

1) Light petroleum-ethylacetate (5:5) eluted a colorless substance that was recrystallized from the suitable solvent to give **12(a–c)**. For yields, mps, physical, and analytical data see Table I.

2) Light petroleum-ethylacetate (3:7) eluted a colorless substance which corresponded and proved to be the phosphonate compound **15(a–c)**[2] (m.p, mixed mps and comparative IR spectra).

Similarly, by allowing **5b** (1 g, 0.005 mol) to react with DAP (**3a–c**, 0.01 mol), compounds **12(d–f)** and **8(a–c)** were isolated and characterized (mp, mixed m.p. and comparative IR spectra).

Action of Heat on **12a**: Compound **12a** (0.5 g) was heated in a cold finger sublimator at 230°C (bath temperature) under reduced pressure (5 mm/Hg) for 30 minutes. The compound that sublimed was collected, recrystallized from methyl alcohol to give yellow crystals, proved to be isatin-monoxime **5a** (identified by m.p., mixed mp, and comparative IR spectra). Dimethyl phosphite (DMP, **3a**) was detected in the receiver by the development of a violet color on addition of 3,5-dinitrobenzoic acid in the presence of alkali.[24]

Reaction of 5-Methylisatin (**1b**) *with Triphenylphosphine.* A mixture of **1b** (0.5 g, 0.003 mol) and TPP (**6**, 1.6 g; 0.006 mol) in dry toluene (25 ml) was refluxed for 6 h. After cooling, the precipitated material was filtered off "Filtrate A," recrystallized from cyclohexane to give **17** as colorless needles (0.88 g, 70%), m.p. 213°C Anal. Calcd. for $C_{27}H_{22}NOP$ (407.45):

	C	H	N	P
Found	79.59	5.44	3.43	7.69
	79.32	5.35	3.85	7.73

The residue left after evaporation of "Filtrate A" till dryness, was recrystallized from cyclohexane to give colorless needles (0.75 g; 90%) proved to be TPPO (m.p. and mixed m.p.).

Reaction of 5-Methylisatin with phosphorus ylides (**7a–c**).

General Procedure: To a suspension of 5-methylisatin (**1b**) (1 g, 0.006 mol) in dry toluene (30 ml) was added a solution of the ylide (**7a–c**) (0.008 mol) in the same solvent (20 ml) and the reaction mixture was refluxed for 6–8 h (TLC). The reaction mixture was then evaporated at 60°C *in vacuo*. The solid product was redissolved in methanol (100 ml) and evaporated to dryness in the presence of

silica gel (5 g), then subjected to column chromatography as previously described, using increasing amounts of ethylacetate in light petroleum as eluents to give the following substances: 1) A fraction (up to 9:1 v/v pet. ether-ethylacetate) eluted an orange-red substance that was recrystallized from the suitable solvent to give (**19a–c**). For yields, mps., physical and analytical data see Table I. The next fraction, up to 6:4 v/v, afforded in each case colorless needles, mp 156°C (*ca.* 90% yield) of triphenylphosphine oxide (mp, mixed up and comparative IR spectra).

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