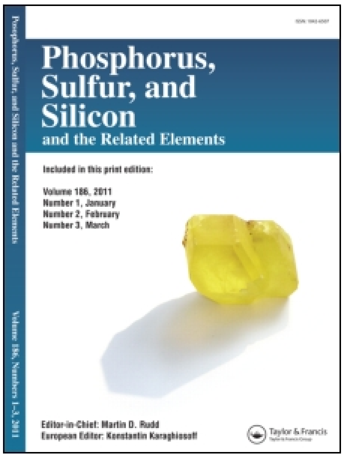

Phosphorus, Sulfur, and Silicon and the Related Elements
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713618290

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To cite this Article Abdou, Wafaa M. and Ganoub, Neven A. F.(1991) 'REACTION OF WITTIG REAGENTS WITH α,α-DIHALOKETONES. DIBENZOYLMETHANE DIBROMIDE AND 1,3-INDANDIONE DIBROMIDE', Phosphorus, Sulfur, and Silicon and the Related Elements, 60: 1, 49 — 55

To link to this Article: DOI: 10.1080/10426509108233924

URL: http://dx.doi.org/10.1080/10426509108233924

Phosphorus, Sulfur, and Silicon, 1991, Vol. 60, pp. 49–55
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REACTION OF WITTIG REAGENTS WITH α, α-DIHALOKETONES. DIBENZOYLMETHANE DIBROMIDE AND 1,3-INDANDIONE DIBROMIDE

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(Received August 27, 1990; in final form October 2, 1990)

Dibenzoylmethane dibromide (**5**) and 1,3-indandione dibromide (**6**) react with ylide-phosphoranes **1a–c** to give the α,β-unsaturated esters **10** and **13**, respectively. All intermediates are isolated and identified. Structures **10** and **13** as well as the intermediates were confirmed by compatible analytical and spectroscopic results.

Key words: Halogeno-ketones; dibenzoylmethane dibromide; 1,3-indandione dibromide; ylide-phosphoranes.

INTRODUCTION

The nucleophilic character of phosphonium ylides has long been recognized, and reactions of this class of compounds with a wide variety of electrophilic reagents have been reported.[1] Among these, however, reactions with α-halogenocarbonyl compounds have received less attention. Bestmann and coworkers[2–4] found that stable alkylidenephosphoranes of type **1** react with α-bromo- or α-iodoacetates (**2**) to form salts **3** which can decompose to α,β-unsaturated esters (**4**) via the ylide or directly from the phosphonium salt.

$$\underset{\mathbf{1}}{Ph_3P = CHR^1} \longrightarrow \underset{\mathbf{3}}{Ph_3P^+CHR^1CH_2CO_2R^2}\ \ X^- \longrightarrow Ph_3P$$

$$+ \qquad\qquad\qquad\qquad + \ {}^1RCH = \underset{\mathbf{4}}{CHCO_2R2}$$

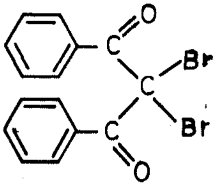
$$\underset{\mathbf{2}}{XCH_2CO_2R^2}$$

During the course of our studies on the behavior of dibenzoylmethane dibromide (**5**) and 1,3-indandione dibromide (**6**) toward organophosphorus compounds,[5] we found it of interest to examine its reactivity toward some Wittig reagents (**1a–c**).

$Ph_3P{=}CHR$

1

1	R
a	$COOCH_3$
b	$COOC_2H_5$
c	COC_6H_5



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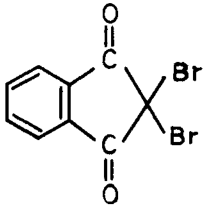

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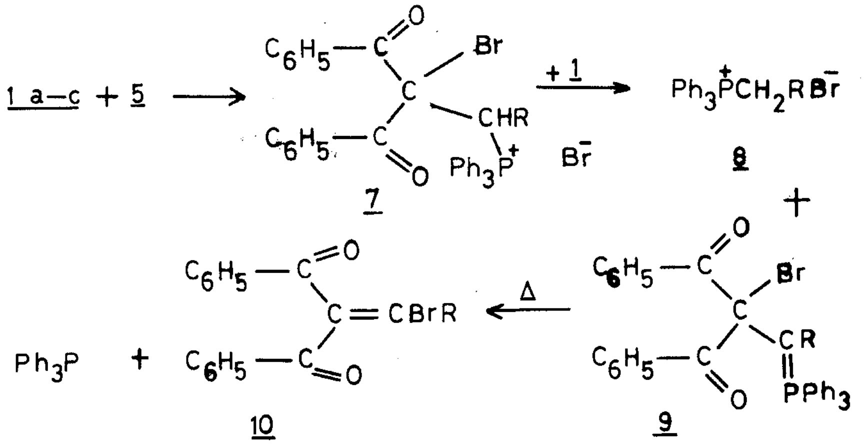
RESULTS AND DISCUSSION

When dibenzoylmethane dibromide (**5**) was treated with one equivalent of methoxy-(**1a**), ethoxy-(**1b**) and/or phenylcarbonylmethylenetriphenylphosphoranes (**1c**) in benzene at r.t., a colorless 1:1 adducts of the corresponding phosphonium salt (**7a–c**) were isolated in good yields ($\sim$ 80%). They are reasonably stable in absence of both air and moisture as well as freely soluble in dilute aqueous alkali. The structure of the new salts (**7a–c**) is assignable from their analyses, IR and NMR spectral data. The IR spectrum of **7a**, disclosed the presence of absorption bands at 1740 cm^{-1} $\left(\rangle C{=}O, \text{ ester}\right)$, 1710 cm^{-1} $\left(\rangle C{=}O, \text{ aryl ketone}\right)$ and at 1440 cm^{-1} [P—C—(phenyl)].[6] In the ^{1}H NMR spectrum of **7a**, signals at δ 3.55 (3H, COOC$\underline{H}_3$, s) and at δ 7.6–8.0 ppm (25H, Ar-$\underline{H}$, m), are present. The methine proton appeared as a doublet ($^{2}JHP = 22.5$ Hz)[6] at 5.25 ppm. In ^{31}P NMR spectrum of **7a** a signal at δ + 20.28 ppm was observed.[7] When the isolated γ-ketophosphonium salts **7a–c** were treated with another equivalent of an appropriate Wittig reagent **1a–c** in refluxing benzene, the respective ylide (**9a–c**) (in $\sim$ 65% yield, based upon the γ-keto-phosphonium salt) was obtained (Scheme I). The parallel Wittig-reagent bromine salt (**8a–c**) could also be isolated and identified in each case. Compounds **9** are equally obtained, (in *ca*, 60% yield) when **5** (one mole) was allowed to react with two mole equivalents of the Wittig reagents (**1a–c**) in boiling benzene for 12 h. Reasons for structure **9** were: (a) Correct elementary

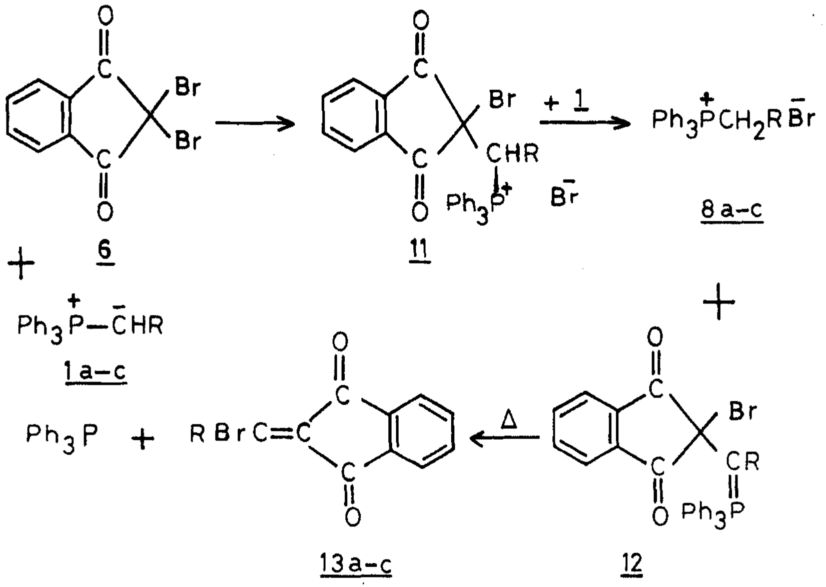


1,7–10	R	^{31}P NMR(δ) 7	9
a	COOCH$_3$	20·28	19·14 ppm
b	COOC$_2$H$_5$	20·36	19·05 ppm
c	COC$_6$H$_5$	17·73	22·92 ppm

Scheme I

analyses and molecular weight determinations by (MS) were obtained for all products. (b) Adducts **9** possess ylide-phosphorane structure, since they exhibit a positive shift in their ^{31}P NMR spectra (*vs.* 85% H_3PO_4) and absorb in the region characteristic for this class of compounds.[7–9] Moreover, the IR spectra of adducts **9** reveal the presence of strong bands around 1680 and 1510 cm^{-1} characteristic for the >C = P< group absorption[8] and around 1450 cm^{-1} for the P—C—(phenyl) absorption.[6] (c) Their ^{1}H NMR spectra revealed the lack of the signals due to the methine proton present in the PMR spectra of the parent compounds **7** at *ca.* δ 5.0 ppm. (d) The ^{13}C NMR (δ) spectrum (400 MHz) of compound **9a** (in CDCl$_3$) exhibited a doublet at 52.84 ppm (—>P = C, J = 130 Hz) and two (aryl ketones) carbonyl groups at 185.24 and 178.62 ppm while the ester carbonyl group appeared at 169.30 ppm, the methoxy group was revealed at 54.13 ppm. (e) Upon thermolysis, compounds **9a–c** yielded triphenylphosphine and the appropriate α,β-unsaturated ester **10a–c** (Scheme I). The olefinic compounds **10** are chromatographically pure and possess sharp melting points. Structure **10** was deduced on the basis of IR, ^{1}H-, ^{13}C NMR, MS and elemental analyses. In the ^{1}H NMR spectrum of **10a**, signals appeared at δ 3.80 ppm (3H, $C\underline{H}_3$, s), δ 7.77 ppm (10 H, Ar-$\underline{H}$, m). Moreover, the ^{13}C NMR spectrum of **10a** shows the lack of the signal at δ 52 ppm due to the —>P = C< ; instead new signals at δ 128.53 and δ 131.76 ppm appeared due to >C = C<. Other signals are disclosed in the ^{13}C NMR of **7a** are still present in the same ranges. In the MS spectrum of **10a**, a signal for m/z = 373 (M$^+$, 42%) was present. In addition, the IR spectrum of **10a** shows bands at 1735 cm^{-1} (>C=O, ester), 1700 cm^{-1} (>C=O, aryl ketones) and at 1620 cm^{-1} (>C=C<).

Next, the reaction of 1,3-indandione dibromide (**6**) with Wittig reagents **1a–c** was also investigated. When **6** was treated with one equivalent of ylide in benzene at r.t., γ-keto-phosphonium salts (**11a–c**) were obtained, respectively, in good yields. On the other hand, carrying out the above reaction in boiling benzene, using two moles of the phosphonium ylide (**1**) instead of one, or allowing **11** to react with another equivalent of (**1**), the new ylides **12** accompanied by the appropriate phosphonium salts **8a–c** were obtained. Pyrolysis of ylides **12** gave rise to the production of the α,β-unsaturated esters **13a–c**. The structures of the new compounds **11–13** were established from their elemental analyses and spectral properties which are consistent with expectation. For instance, elemental analysis and molecular weight determination (MS) for the keto-ester **13a**, taken as an example, agreed with the molecular formula $C_{12}H_7BrO_2$ (m/z, 263, M$^+$, 48%). (b) Its IR spectrum showed strong absorption bands at 1735 (>C=O, esters), 1690 (>C=O, aryl ketones) and 1625 cm^{-1} (>C=C<). (c) The PMR spectrum of



^{31}P NMR (δ)

1,11–13	R	11	12
a	$COOCH_3$	21·47	18·59 ppm
b	$COOC_2H_5$	21·53	18·31 ppm
c	COC_6H_5	17·84	22·60 ppm

SCHEME II

13a disclosed the presence of signals at δ 3.90 (3H, $COOC\underline{H}_3$ – s) and at 8.17 ppm (4H, Ar-$\underline{H}$, m). Moreover, the signal due to the $-\overset{|}{\underset{|}{C}}-C\underline{H}$ proton present in the PMR spectrum of **11a** at δ 5.2 ppm was absent in the spectrum of **13a**. The presence of the exocyclic $>C{=}C<$ in **13a** was attested by signals at δ 129.3 and 135.5 ppm in its ^{13}C NMR spectrum. The spectrum also showed signals at δ 50.47 ppm ($-O\underline{C}H_3$), δ 169 ppm $\left(>C{=}O\text{, ester}\right)$, δ 185.3 ppm and 190.5 ppm $\left(>C{=}O\text{, aryl ketones}\right)$.

Formation of compounds **10** and/or **13** can be explained by the initial nucleophilic attack by the carbanion centre in the ylide **1** on the more reactive midstanding carbon[10,11] in **5** and/or **6** to give the γ-keto-phosphonium halides **7** and/or **11** which subsequently lead to new ylides **9** and/or **12** by a transylidation reaction (Scheme I and II). The hydrogen atom in the β-position to the phosphorus atom is strongly activated,[2,3] and such ylides readily decompose by a Hofmann[12] elimination to unsaturated esters **10** and/or **13** and triphenylphosphin.

CONCLUSION

From the results of the present investigation, it could be noticed that the reaction of α-halogenocarbonyl compounds with stable alkylidenephosphoranes is well suited to the formation of complicated phosphorus ylides which are often unavailable by other methods.[13] These ylides can be converted into alkanes or alkenes by hydrolysis or thermolysis, respectively, besides, being useful for further Wittig reactions.

EXPERIMENTAL

All melting points are uncorrected. The benzene used was dried over Na. Carbmethoxymethylene,[14] carbethoxymethylene,[14] and benzoylmethylene-triphenylphosphorane[15] were prepared according to es-

TABLE Ia

Physical and spectral properties of the products **7** and **9–13**, derived from the reactions of halogeno-ketones **5** and **6** with ylide-phosphoranes **1**

Cpd,	Yield in %[a]	mp. °C	Mol. form. M.wt	Analysis (calcd./found)				M+ m/z	IR cm−1		
				C	H	Br	P				
7a	88	168[b]	$C_{36}H_{29}Br_2O_4P$	60.35	4.08	22.30	4.32	—	1740	1710	1440
			716.42	60.27	4.05	22.12	4.28	716	C=O	C=O	P—C
b	85	145[b]	$C_{37}H_{31}Br_2O_4P$	60.84	4.27	21.88	4.24	—	1743	1715	1440
			730.447	60.77	4.05	21.83	4.19	730	C=O	C=O	P—C
c	90	235[b]	$C_{41}H_{31}Br_2O_3P$	64.58	4.10	20.96	4.06	—	1710	1695	1432
			762.491	64.53	4.12	20.83	4.02	762	C=O	C=O	P—C
9a	65	120[c]	$C_{36}H_{28}BrO_4P$	68.04	4.44	12.57	4.87	—	1745	1680 and 1510	
			635.503	67.79	4.41	12.29	4.83	635	C=O	C=P	
b	60	95[c]	$C_{37}H_{30}BrO_4P$	68.42	4.65	12.30	4.77	—	1742	1685 and 1512	
			649.53	68.36	4.64	12.28	4.66	649	C=O	C=P	
c	65	132[c]	$C_{41}H_{30}BrO_3P$	72.25	4.43	11.72	4.54	—	1740	1680 and 1515	
			681.574	72.18	4.41	11.69	4.43	681	C=O	C=P	
10a	45	66[d]	$C_{18}H_{13}BrO_4$	57.93	3.51	21.41	—	—	1735	1700	1620
			373.211	57.88	3.47	21.29	—	373	C=O	C=O	C=C
b	45	55[d]	$C_{19}H_{15}BrO_4$	58.93	3.90	20.63	—	—	1735	1705	1622
			387.238	58.87	3.87	20.56	—	387	C=O	C=O	C=C
c	35	82[d]	$C_{23}H_{15}BrO_3$	65.88	3.60	19.06	—	—	1750	1695	1622
			419.282	65.86	3.56	18.95	—	419	C=O	C=O	C=C
11a	90	>300[b]	$C_{30}H_{23}Br_2O_4P$	56.45	3.63	25.03	4.85	—	1755	1695	1445
			638.306	56.41	3.58	24.87	4.69	638	C=O	C=O	P—C
b	90	280[b]	$C_{31}H_{25}Br_2O_4P$	57.08	3.86	24.50	7.74	—	1750	1695	1447
			652.333	57.03	3.82	24.47	4.67	652	C=O	C=O	P—C
c	90	>300[b]	$C_{35}H_{25}Br_2O_3P$	61.42	3.68	23.35	4.52	—	1700 -	(broad)	1435
			684.377	61.38	3.62	23.29	4.27	684	C=O		P—C
12a	75	135[c]	$C_{30}H_{22}BrO_4P$	64.64	3.97	14.33	5.55	—	1752	1682 and 1510	
			557.389	64.58	3.95	13.87	5.46	557	C=O	C=P	
b	72	110[c]	$C_{31}H_{24}BrO_4P$	65.16	4.23	13.98	5.42	—	1755	1675 and 1515	
			571.416	64.67	4.21	13.85	5.26	571	C=O	C=P	
c	65	155[c]	$C_{35}H_{24}BrO_3P$	69.66	4.01	13.24	5.13	—	1695(br.)	1678 and 1520	
			603.46	69.49	3.85	13.05	5.08	603	C=O	C=P	
13a	40	85[d]	$C_{12}H_7BrO_4$	48.84	2.39	27.08	—	—	1735	1690	1625
			295.097	48.76	2.37	26.86	—	295	C=O	C=O	C=C
b	42	72[d]	$C_{13}H_9BrO_4$	50.51	2.93	25.85	—	—	1738	1695	1620
			309.124	50.47	2.88	25.79	—	309	C=O	C=O	C=C
c	35	135[d]	$C_{17}H_9BrO_3$	59.85	2.66	23.42	—	—	1695	(broad)	1622
			341.168	59.80	2.63	23.28	—	341	C=O		C=C

[a] Yields are approximated.
[b] Solvent of crystallization is DMSO.
[c] Solvent of crystallization is C_2H_5OH.
[d] Solvent of crystallization is cyclohexane.

tablished procedures. The IR spectra were measured in KBr, on Perkin-Elmer Infracord Spectrometer Model 157 (Grating). The PMR spectra were run on Varian Spectrometer at 90 MHz, using TMS as an internal reference. ^{31}P and ^{13}C NMR spectra were recorded with a Varian FT-80 Spectrometer. ^{31}P NMR spectra were recorded relative to external H_3PO_4 (85%). ^{13}C NMR spectra were recorded relative to internal TMS. The mass spectra were run at 70 eV on Kratos MS-50 equipment provided with a data system.

Preparation of γ-keto-phosphonium salts **7** *and* **11**. To a suspension of dibromide **5**[16] and/or **6**[17] (0.01 mole) in absolute benzene (10 ml), was added ylide **1(a–c)** (0.01 mole) in benzene (10 ml) and the reaction mixture was left at room temperature under stirring for 24–36 h (TLC). The colorless precipitated material was filtered off, washed with benzene (2 ml) and recrystallized from 2 ml of H_2O to give **7** and/or **11** as colorless crystals. Physical and analytical data for compounds **7** and **11** are presented in Table I.

Preparation of the new ylides **9** *and* **12**. To a suspension of dibromide **5** and/or **6** (0.01 mole) in absolute benzene 20 ml, was added ylide **1(a–c)** (0.022 mole) in benzene (15 ml) and the reaction mixture was refluxed under stirring for 12–18 h. After the reaction was completed (TLC), the volatile materials were evaporated and the residue was triturated with boiling water (3 ml) and filtered. The solid so collected, was dried and recrystallized from a suitable solvent to give compounds **9** and/or **12**. Physical and analytical data for compounds **9** and **12** are presented in Table I.

The water filtrate afforded, upon concentration and cooling, the respective alkylidene-phosphonium salt **8a–c** (TLC, comparative IR and PMR spectra).

When the reaction was performed using equimolar amounts from the prepared γ-ketophosphonium salt **7a–c** and/or **11a–c** and the ylides **1a–c**, the ylides **9** and/or **12** accompanied with the appropriate phosphonium salt **8a–c** were obtained. Physical and analytical data are compiled in Table I.

Preparation of α,β-unsaturated esters **10** *and* **13**. The ylide adduct **9a** (1g) was heated (bath temp. 230°C) for one hour under reduced pressure (5 mm/Hg) in a cold finger sublimator. The reaction vessel

TABLE Ib

	^{1}H NMR[a] (δ) ppm			
Compound	$C—CH_3$	OCH_3, OCH_2	C—H	Ar—H
7a[b]	—	3.55(s, 3H)	5.25(d, 1H)	7.80(m, 25H)
	—	—	J_{HP} = 22.5Hz	—
b[b]	1.02(t, 3H)	4.00(q, 2H)	5.46(d, 1H)	7.70(m, 25H)
	J_{HH} = 8Hz	J_{HH} = 8Hz	J_{HP} = 24Hz	—
c[b]	—	—	5.63(d, 1H)	7.76(m, 30H)
	—	—	J_{HP} = 24Hz	—
9a[c]	—	3.52(s, 3H)	—	7.80(m, 25H)
b[c]	1.04(t, 3H)	3.03(q, 2H)	—	7.78(m, 25H)
c[c]	—	—	—	7.80(m, 30H)
10a[c]	—	3.80(s, 3H)	—	7.77(m, 10H)
b[c]	1.10(t, 3H)	4.15(q, 2H)	—	7.76(m, 10H)
c[c]	—	—	—	7.69(m, 15H)
11a[b]	—	3.98(s, 3H)	4.72(d, 1H)	7.82(m, 19H)
	—	—	J_{HP} = 23Hz	—
b[b]	1.42(t, 3H)	4.47(q, 2H)	4.80(d, 1H)	7.84(m, 19H)
	—	—	J_{HP} = 22Hz	—
c[b]	—	—	4.89(d, 1H)	8.15(m, 24H)
	—	—	J_{HP} = 22Hz	—
12a[c]	—	4.08(s, 3H)	—	8.24(m, 19H)
c[c]	1.52(t, 3H)	4.62(q, 2H)	—	8.52(m, 19H)
c[c]	—	—	—	8.57(m, 24H)
13a[c]	—	3.90(s, 3H)	—	8.17(m, 4H)
b[c]	1.40(t, 3H)	4.40(q, 2H)	—	8.05(m, 4H)
c[c]	—	—	—	8.35(m, 9H)

[a] See experimental for details of NMR experiments.

[b] The solvent is DMSO.

[c] The solvent is $CDCl_3$.

TABLE Ic

(^{13}C-NMR spectral data[a])

Cpd./C[b]	C_1	C_2	C_3	C_4	C_5	$C_{5'}$
9a	52.84	54.13	62.36	169.30	178.62	185.24
10a	54.71	128.53	131.76	169.38	178.59	185.16
12a	53.58	54.69	65.14	169.62	185.82	190.04
13a	50.47	129.36	135.54	169.02	185.30	190.53

[a] See experimental for details of NMR experiments.

[b] The numbering system is as in Figures, 1, 2.

[c] The solvent is $CDCl_3$.

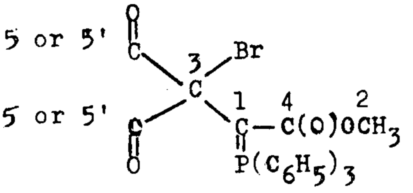


FIGURE 1

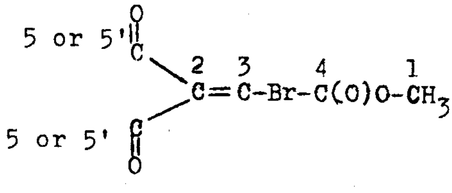


FIGURE 2

was left to cool and ethyl alcohol (5 ml) was added. The crystals which separated were recrystallized from ethanol to give **10a**.

The ethanol filterate afforded upon evaporation and adding a few drops of n-pentane, triphenylphosphine (identified by mp., mixed mp. and comparative IR spectra).

In a similar manner, compounds **10b, c** and **13a–c** were obtained upon thermal decomposition of **9b, c** and/or **12a–c** respectively. Physical and spectroscopic results for **10** and **13** are listed in Table I.

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