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Investigating the Mechanism of 1,3,5-Cycloheptatriene Formation: Condensation of 1-Methylethyl 3-Oxo-4-(triphenylarsoranylidene)butanoate with 7-Methoxy-3,7-dimethyloctanal

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ABSTRACT: *Condensation of [3-(1-methylethoxycarbonyl)-2-oxopropyl]triphenylarsonium bromide* **8** *with 7-methoxy-3,7-dimethyloctanal* **10** *in the presence of a base gave bis(1-methylethyl) 4,7-dihydroxy-2-(6-methoxy-2,6-dimethylheptyl)-3,5,7-cycloheptatriene-1,3-dicarboxylate* **7b.** *The formation of* **7b** *can be explained by a number of consecutive steps. The mechanism, strongly supported by liquid secondary ion mass spectrometry, suggests that an aldol condensation of the γ-arsonium ylide* **2b** *and the aldehyde* **10** *takes place as the initiating step and is followed by a Michael addition of the aldol product and the γ-arsonium ylide* **2b.** *Then an intramolecular nucleophilic substitution and elimination of triphenylarsine, followed by base-catalyzed elimination of a second molecule triphenylarsine takes place to produce* **7b.**
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INTRODUCTION

For more than three decades, it has been demonstrated that the phosphonium ylide **1** [1] and recently also the arsonium ylide **2** of alkyl 3-oxobutanoates (acetoacetate esters) have remarkable synthetic potential (Scheme 1). For example, condensations of the phosphonium ylide **1** with aldehydes gave the expected γ,δ-unsaturated-β-keto esters **3** [2]. For both types of ylides **1** and **2,** reaction with unsaturated carbonyl compounds gave, via a Michael–Wittig condensation, cyclohexenonecarboxylates **5** and **6,** respectively [3,4]. Five-membered cyclic compounds **4** have also been prepared from **1** [5]. We have published a preliminary report on the preparation of symmetrical substituted 1,3,5-cycloheptatrienes **7** [6]. For example, **7a** formed during condensations of 1-methylethyl 3-oxo-4-(triphenylarsoranylidene)butanoates **2** with propanal (Scheme 1).

1,3,5-Cycloheptatrienes are potentially useful intermediates in organic synthesis [7,8]. This requires that suitable functionalized cycloheptatrienes can easily be prepared [9]. A number of 1,3,5-cycloheptatriene syntheses starting from tropones [9] tropylium salts [10] or from cyclopropanation of quinones [11,12] and other methods [13] have been developed. Recently, a novel ring enlargement of *ortho*-quinones to 3-hydroxytropones with stabilized bismuthonium ylides has been communicated [14]. Our method offers a new technique for the synthesis of cycloheptatrienes **7** from condensations of the acetoacetate

Dedicated to Prof. Dr. Heinrich Nöth on the occasion of his seventieth birthday.

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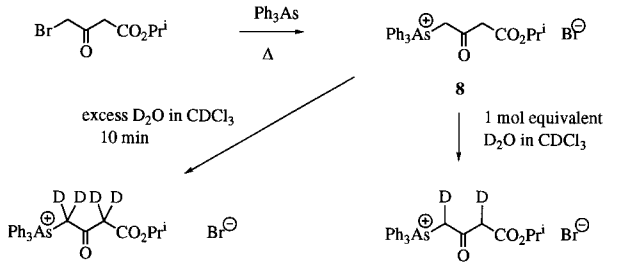
arsonium ylide **2** and aldehydes [6] and is suitable for the synthesis of bridged annulenes [15]. In this article, we describe the mechanism of the unique formation of cycloheptatrienes **7.**

RESULTS AND DISCUSSION

Preparation and Characterization of 1-Methylethyl 3-Oxo-4-(triphenylarsoranylidene)butanoate **2b.** 1-Methylethyl 4-bromo-3-oxobutanoate [1,16] was heated with triphenylarsine to give the white arsonium salt **8** [17]. ^1H and ^{13}C NMR ($CDCl_3$) spectroscopy showed only the keto form **8.** Addition of a little D_2O led to deuterium exchange in less than 2 minutes on both the γ- and α-methylene positions; no noticeable preference for either the γ- or α-position was found (Scheme 2). Excess D_2O led to full deueration in less than 10 minutes. This result is also indicative that condensations of deprotonated arsonium salt **8** with aldehydes that may take place at an equal rate either at the α- or at the γ-position.

Treatment of the arsonium salt **8** in dichloromethane with an aqueous solution of sodium bicarbonate gave the isolable arsonium ylide **2b.** NMR spectroscopy only revealed the α-ylide. However, the ylide **2b** was not very stable to moisture or even to mild elevated temperatures [17].

Further evidence of the ambident nucleophilicity of the arsonium ylide **2b** was obtained when a solution of the arsonium salt **8** in $CDCl_3$ dissolved zinc



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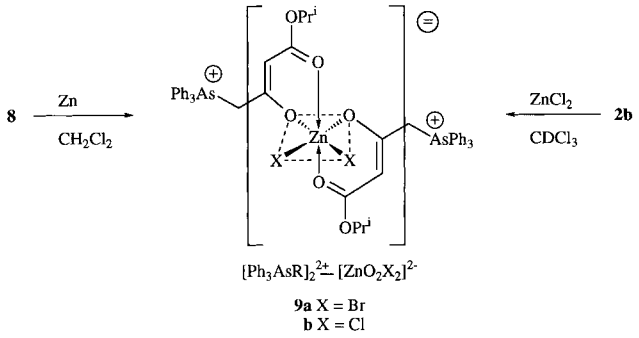

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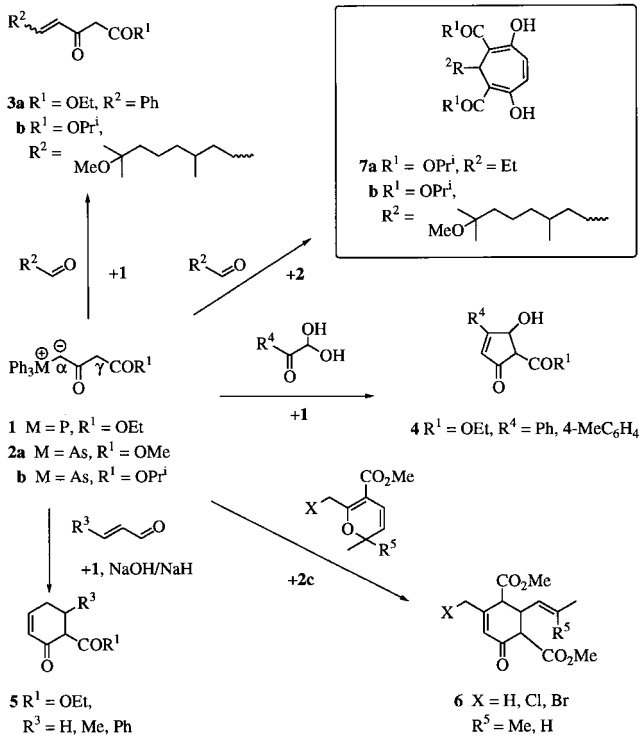
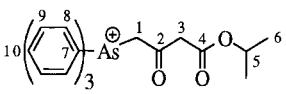
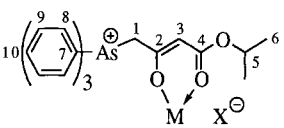


SCHEME 1

TABLE 1 ^{13}C Chemical Shifts (δ_C in ppm) of Compounds **8, 2b, 9a,** and **9b**[a]



8 arsonium bromide
2b arsonium ylide



9a M = Zn, X = Br
b M = Zn, X = Cl

C-No	**8** *$CDCl_3$*	**2b** *C_6D_6*	**9a** *$CDCl_3$*	**9b** *$CDCl_3$*
1	42.43	57.33	39.62	39.14
2	196.62	181.25	174.24	174.85
3	49.05	47.25	87.90	88.97
4	166.09	170.25	172.73	173.29
5	68.95	67.46	68.06	68.67
6	21.08	21.99	21.71	21.64
7	120.95	128.96	121.87	121.65
8	130.13	132.74	132.83	132.66
9	132.24	129.56	130.59	130.62
10	133.42	131.86	133.75	133.82

*a*At 50.3 MHz.

TABLE 2 ^{1}H Chemical Shifts (δ_H in ppm) of Compounds **8, 2b, 9a,** and **9b**[a]

	8		**2b**		**9a**		**9b**	
H-No	*$CDCl_3$*	*J*	*C_6D_6*	*J*	*$CDCl_3$*	*J*	*$CDCl_3$*	*J*
1	6.092	s	4.15	br.s	4.179	s	4.287	s
3	4.085	s	3.53	br.s	4.853	s	4.965[b]	s
5	4.989	h, 6.3	5.133	h, 6.2	4.971	h, 6.2	4.923	h, 6.2
6	1.208	d, 6.3	1.164	d, 6.2	1.120	d, 6.2	1.138	d, 6.2
8, 9, 10	7.82–7.60	m	7.04–7.36, 7.59–7.69	2 × m	7.78–7.60	m	7.74–7.58	m

[a]At 200 MHz and *J* measured in Hz.
[b]Isomer at 5.304 (~25%).

metal, liberating hydrogen, and the organometallic intermediate formed coordinating with zinc bromide to form the complex $\{[Ph_3AsR]_2^{2+}—[ZnO_2Br_2]^{2-}]\}$, the chelated structure being represented by **9a** (Scheme 3) [18]. Closer examination showed that the solution first became yellow in the vicinity of the zinc metal, due to the formation of the bidentate arsonium ylide **2b,** which then reacted with zinc bromide to form the colorless zinc complex **9a.** We noticed, however, some exchange of bromide with chloride in the liquid secondary ion mass spectrum (LSIMS) of **9a,** this being due to chlorine exchange with $CDCl_3$. The arsonium ylide **2b** reacted with zinc chloride to give **9b** (Scheme 3). In general, zinc chloride complexes are quite common [19] while *β*-diketone-zinc complexes [20] and zinc ester enolates are also known [21]. Tables 1 and 2 summarize the ^{13}C- and ^{1}H-NMR spectra of compounds **8, 2b,** and **9.**

Condensation of 1-Methylethyl 3-oxo-4-(triphenylarsoranylidene)butanoate **2b** *with 7-Methoxy-3,7-dimethyloctanal* **10.** Condensation of the ylide **2b** and 7-methoxy-3,7-dimethyloctanal **10** at room temperature in toluene gave, after chromatographic separation, triphenylarsine. Further chromatography gave the pale yellow cycloheptatriene **7b** and the almost colorless cyclohexenonedicarboxylate **11** (Figure 1). In $CDCl_3$, the cycloheptatriene **7b** at room temperature existed only as the diol-tautomer. However, on TLC (ether:hexanes, 1:1), a faint spot also developed at a slightly lower R_f value. We believe that this spot may represent the enolketo-tautomer of **7b.** In a recent communication, a benzocycloheptadionedicarboxylate was also found to be completely enolized as the benzocycloheptatriene tautomer [22]. Other Wittig condensations are known to produce seven-membered carbocycles with two enolizable keto-groups in conjugation with an alkene [23]. Preparations of unsaturated seven-membered carbocycles via Wittig condensations have been developed [24].

In general, the valence tautomerism between derivatives of 1,3,5-cycloheptatriene and bicyclo[4,1.0]hepta-2,4-diene (norcaradiene) at room temperature is almost totally shifted to the 1,3,5-cycloheptatriene tautomer [25]. However, steric effects on the 1,3,5-cycloheptatriene ring system and/or the presence of electron-withdrawing groups in position 7 and/or electron-donating groups in positions 3 and 4 appear to favor the equilibrium toward the norcaradiene tautomer [26,27]. For the cycloheptatriene **7b** in $CDCl_3$, no trace of the norcaradiene tautomer at room temperature could be found. No cycloaddition of **7b** and nitroethylene in CH_2Cl_2 occurred during 3 days at room temperature, which is in agreement with the literature [8].

In D_2O, both enol protons of **7b** were deuterated within 24 hours. The mass spectrum of **7b** showed a base peak at $m/z = 295$ due to the tropylium ion [28] (Figure 2). The ^{1}H-NMR spectrum of **7b** showed nonequivalence of the isopropyl groups and enol protons and the ^{13}C-NMR spectrum of **7b** showed a further nonequivalence in the cycloheptatriene ring carbons due to restricted rotation of the isopropyl groups. The boat conformation of **7b** is such that the alkyl substituent is in the equatorial position (Figure 2) [29].

Optimization of cycloheptatriene **7b** was difficult. The in situ preparation of the arsonium ylide **2b** from the salt **8** and KO*t*-Bu (THF, 0°C) and the condensation with 7-methoxy-3,7-dimethyloctanal **10** gave neither **7b** nor the cyclohexenone **11.** However, the expected 1-methylethyl 10-methoxy-7,10-dimethyl-3-oxo-4-dodecenoate **3b** was isolated in a rather low yield. Use of lithium and sodium carbonate gave the highest yield of **7b** (Table 3). The enolate intermediates of lithium and sodium enhance the formation of **7b,** while the ionic potassium enolate favors the production of the classical Wittig condensation product **3b** [30,31].

The Proposed Mechanism for the Formation of the Cycloheptatriene **7b** *and Cyclohexenone* **11.** To rationalize the formation of **7b,** we first had to investigate the characteristic features of the arsonium compounds **8** and **2b.** It was then found that depro-

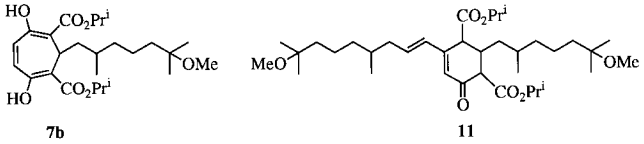


FIGURE 1 Compounds isolated from the condensation of **2b** and **10.**

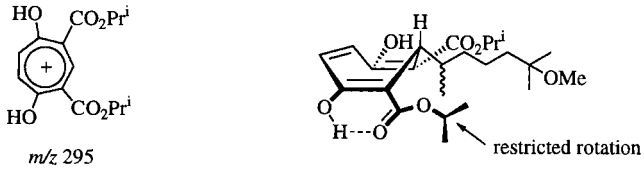
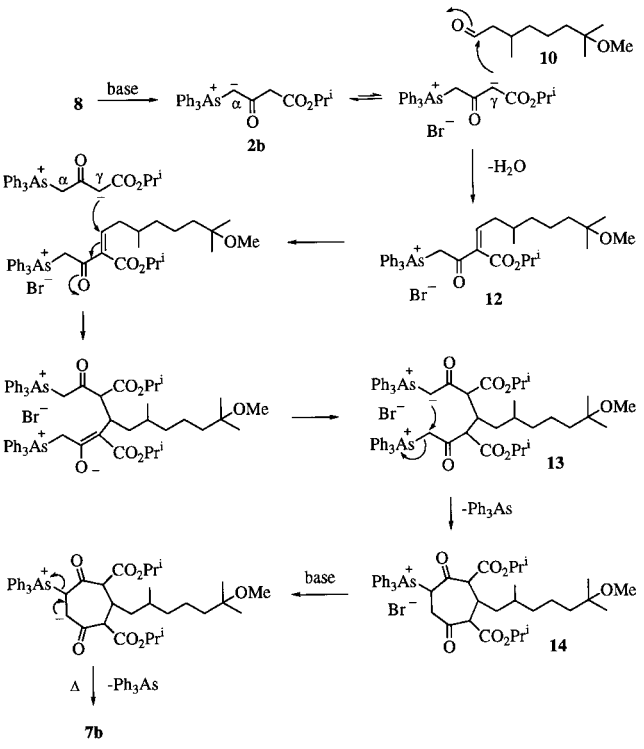


FIGURE 2 Spectroscopic characteristics of cycloheptatriene **7b.**



SCHEME 4 Proposed mechanism for the formation of the cycloheptatriene **7b.**

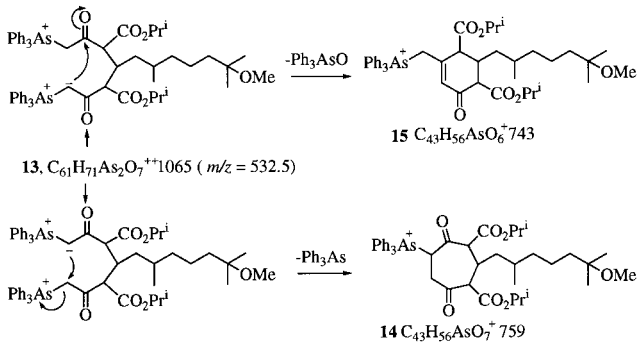
tonation of **8** can take place either at the α- or the γ-positions. We also established from previous experience that the arsonium ylide **2b** is in equilibrium with the γ-ylide of **2b** [4]. Thus, there is an equal possibility of an aldol condensation taking place between the aldehyde **10** and **2b** at the γ-position of **2b** to form, after elimination of water, the intermediate arsonium species **12** (Scheme 4), or a Wittig condensation of **2b** and **10** to give, after expulsion of $Ph_3As=O$, the unsaturated β-keto ester **3b.** In general, for Wittig condensations, elimination of $Ph_3P=O$ is more facile than the elimination of $Ph_3As=O$. On the other hand, elimination of Ph_3As is well known and elimination of Ph_3P is rather rare during Wittig condensations. Michael addition of the γ-ylide of **2b** and **12** may form the intermediate **13.** This is especially true because there are two strong electron-withdrawing groups in structure **12.** We [31] and others [3] have come to the conclusion that Michael addition of the phosphonium ylide **1** to unsaturated carbonyl compounds is much faster than intermolecular Wittig condensations, especially when the carbonyl group is sterically hindered. This phenomenon is also true for the arsonium ylide **2b** [4]. Therefore, an intramolecular attack of **13,** followed by elimination of triphenylarsine, could have led to the arsonium species **14.** A further base-induced elimination of triphenylarsine of **14** could have furnished **7b.**

To obtain experimental evidence for the proposed mechanism for the formation of the cycloheptatriene **7b,** the reaction mixture in run 1 (Table 3) was periodically analyzed with liquid secondary ion

TABLE 3 Reactions of Compounds **7b** and **3b**

Run	Base	Reaction Conditions Time and Temperature	Yield, % Ph_3As	**7b**	**3b**
1	Li_2CO_3	40 h rt, 24 h at 60°C	59	32	0
2	Na_2CO_3	40 h rt, 24 h at 60°C	54	39	9
3	$KOBu^t$	5 h rt	14[a]	0	24
4	2 × LDA	2 h rt	20	16	23

[a]Formation of Ph_3As is due to nonhydrolytic decomposition of **2b** [17].



SCHEME 5 Mass spectral ions observed in LSIMS.

mass spectrometry (LSIMS) (Figure 3). At least one double-charged ion in LSIMS was found at *m/z* = 532, suggesting a bis-arsonium species. The most intense and also, over time, the most stable ion at *m/z* = 759 suggested an intermediate such as the arsonium species **14** (Scheme 5). Another intense peak at *m/z* = 743 may be attributed to arsonium intermediate **15,** which, after a Wittig condensation with aldehyde **10,** may give the cyclohexenonedicarboxylate **11.** It is appropriate to note that complex polar phosphonium compounds have been isolated when the corresponding phosphonium ylide **1** condensed with carbonyl substrates [32].

The LSIMS results over a period of time seem to suggest that arsonium intermediate **13** is either prone to elimination of Ph_3As to give, via the arsonium intermediate **14,** cycloheptatriene **7b.** Or the intermediate **13** may undergo an intramolecular Wittig condensation to give intermediate **15.** After another Wittig condensation of this intermediate **15** with the aldehyde **10,** cyclohexenonedicarboxylate **11** may be isolated. However, our experience with the equivalent phosphonium ylide **1** ($R^1 = Pr^i$) has shown that **11** may also be obtained via another route. An aldol condensation of *β*-keto ester **3b** with **10,** followed by a Michael attack of the *γ*-ylide of **1** ($R^1 = Pr^i$) on this aldol product, gives, after an intramolecular Wittig condensation, cyclohexenonedicarboxylate **11** [31,33].

Chromatography of the reaction mixture described in run 1 in Table 3 gave an uncharacterizable polar mixture of arsonium salts and ylides, together with triphenylarsine oxide. LSIMS analyses of this mixture showed again the arsonium species **14** at *m/z* = 759, excluding any clustering effect of pure **2b** and **10** of the LSIMS technique. Very little of the more reactive intermediate **15** at *m/z* = 743 was observed.

CONCLUSION

Condensation of [3-(1-methylethoxycarbonyl)-2-oxopropyl]triphenylarsonium bromide **8** with 7-methoxy-3,7-dimethyloctanal **10** in the presence of lithium carbonate produced bis(1-methylethyl) 4,7-dihydroxy-2-(6-methoxy-2,6-dimethylheptyl)-3,5,7-cycloheptatriene-1,3-dicarboxylate **7b.** The mechanism for formation of **7b,** strongly supported by liquid secondary ion mass spectrometry (LSIMS), suggests a cascade sequence of aldol condensation and Michael addition reactions, followed by base-catalyzed elimination of triphenylarsine. Biological screening has revealed that the cycloheptatriene **7b** showed some ectoparasiticidal activity.

EXPERIMENTAL

^{1}H-NMR (*δ,* with TMS as an internal standard) and ^{13}C-NMR (*δ*) spectra in $CDCl_3$ or C_6D_6 were recorded on a Varian Gemini-200 spectrometer at 200 MHz and 50.3 MHz, respectively. High-resolution electron ionization (EI) mass spectra, LSIMS, and chemical ionization spectra (CI) using ammonia were obtained by use of a Kratos Concept ISQ instrument. Infrared spectra were obtained on a Hitachi 270-30 FTIR spectrophotometer (film, NaCl plates). Ultraviolet absorbance was measured as solutions in 96% EtOH on a Shimadzu UV-150 spectrophotometer. Microanalyses were performed using a Carlo Erba, CHNS-O EA 1108 Elemental Analyser. Column chromatography was performed using Merck Si-60 (0.040–0.063 mm) silica gel. 7-Methoxy-3,7-dimethyloctanal **10** (Aldrich) was redistilled before use. Light petroleum ether refers to the fraction distilled at 40–60°C. 1-Methylethyl 3-oxobutanoate was obtained from diketene and 2-propanol in the presence of DMAP. 1-Methylethyl 4-bromo-3-oxobutanoate was prepared according to the literature [16].

[3-(1-Methylethoxycarbonyl)-2-oxopropyl]triphenylarsonium Bromide **8.** 1-Methylethyl 4-bromo-3-oxobutanoate (4.40 g, 19.72 mmol) was added neat to triphenylarsine (6.00 g, 19.60 mmol) at room temperature, and the mixture was heated in an oil bath at 80°C. The melt was thoroughly mixed and kept for 2 hours at 80°C. The resulting solid was recrystallized from toluene:2-propanol (3:1) to give **8** (8.55 g, 82.4%). Mp 146°C(dec); anal. calcd for $C_{25}H_{26}AsBrO_3$: C, 56.73; H, 4.95. Found: C, 56.52; H, 5.03. HRMS (LSIMS) calcd for $C_{25}H_{26}AsO_3$ ($M^{+\cdot}$) *m/z* 449.1099; found: 449.1078. ν_{max} (KBr) 1737 (vs), 1711 (s) cm^{-1}. For ^{1}H NMR and ^{13}C NMR, see Tables 1 and 2.

Reaction of Zinc and [3-(1-Methylethoxycarbonyl)-2-oxopropyl]triphenylarsonium Bromide **8.** Excess zinc was added to a solution of **8** (3 mmol) in anhydrous CH_2Cl_2 (5 mL) and refluxed for 24 hours. The solvent was removed under vacuum to give a quantitative yield of **9a** as a white viscous gel. Anal. calcd for $C_{50}H_{50}As_2Br_2O_6Zn$: C, 53.53; H, 4.49. Found: C, 53.23; H, 4.51. MS (LSIMS): 1118 ($C_{50}H_{50}O_6As_2Br^{79}{}_2Zn^{64}$, $M^{+\cdot}$, <1%), 1039 ($M^{+\cdot} - Br^{78}$, 1%), 959 ($M^{+\cdot} - Br - HBr$, 2), 639 (8), 593 (7), 575 (20), 547 (3), 513 (3), 449 (100), 389 (80), 323 (50), 229 (40). ν_{max} (mull, CH_2Cl_2) 1735 (m), 1715 (m), 1620 (s), 1515 (s) cm^{-1}. For ^{1}H NMR and ^{13}C NMR, see Tables 1 and 2.

1-Methylethyl 3-Oxo-4-(triphenylarsoranylidene)butanoate **2b.** A solution of sodium bicarbon-

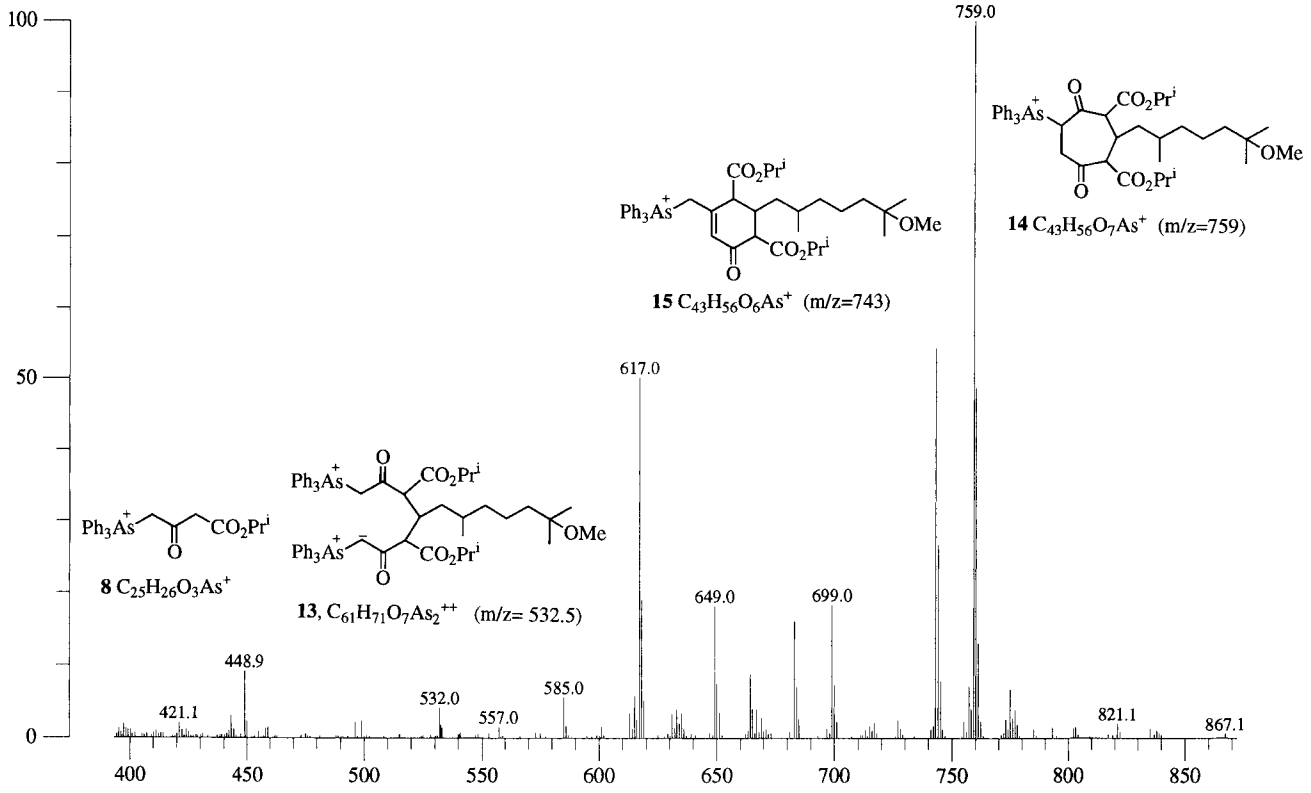
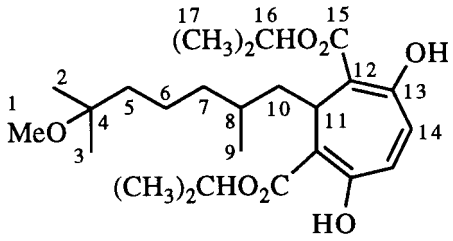


FIGURE 3 Liquid secondary mass spectrum of run 1 (Table 3).

ate (0.70 g, 8.32 mmol) in water (30 mL) was rapidly added to a solution of the arsonium salt **8** (3.10 g, 5.86 mmol) in dichloromethane (20 mL) and vigorously stirred for 2 hours at room temperature. The organic layer was separated, washed with water (2×30 mL), and dried ($MgSO_4$). After filtration, the solvent was removed under reduced pressure to give a yellowish viscous gel of 1-methylethyl 3-oxo-4-(triphenylarsoranylidene)butanoate **2b** (quantitative) that may crystallize on standing. Anal. calcd for $C_{25}H_{25}AsO_3$: C, 66.97; H, 5.62. Found: C, 67.22; H, 5.81. HRMS (LSIMS) calcd for $C_{25}H_{26}AsO_3$ ($MH^{+\cdot}$) *m/z* 449.1099; found: 449.1088. For ^1H NMR and ^{13}C NMR, see Tables 1 and 2.

Addition of anhydrous zinc chloride dioxane complex to a solution of the arsonium ylide **2b** in $CDCl_3$, gave, at once, the bidentate zinc chloride complex **9b.**

Condensation of 1-Methylethyl 3-Oxo-4(triphenylarsorane)butanoate **2b** *and 7-Methoxy-3,7-dimethyloctanal* **10.** Racemic 7-methoxy-3,7-dimethyloctanal **10** (4.40 g, 23.60 mmol) was added to a freshly prepared solution of 1-methylethyl 3-oxo-4-(triphenylarsoranylidene)butanoate **2b** (5.30 g, 11.82 mmol) in anhyd CH_2Cl_2 (30 mL) at room temperature in the presence of hydroquinone (30 mg, 0.27 mmol), magnesium sulfate (0.50 g, 3.61 mmol), and TEBAC (5 mg) for 30 minutes. The reaction mixture was then raised to 38°C and stirred for another 6 hours. Then CH_2Cl_2 was removed, and a mixture of ether:light petroleum ether (1:2) (100 mL) was added to the reaction mixture to precipitate $Ph_3As{=}O$ and unreacted arsonium residues. The suspension was filtered over a bed of silica gel and eluted with ether:light petroleum ether (1:1) (150 mL). The eluate was evaporated, and the residue (6.16 g) was chromatographed on silica gel and slowly eluted with light petroleum ether, ether:light petroleum ether (1:19), (1:9), (3:17) to give, respectively, triphenylarsine (1.26 g, 34.8%), bis(1-methylethyl) 4,7-dihydroxy-2-(6-methoxy-2,6-dimethylheptyl)-3,5,7-cycloheptatriene-1,3-dicarboxylate **7b** (230 mg, 8.6%) as a pale yellow oil. Anal. calcd for $C_{25}H_{40}O_7$: C, 66.35; H, 8.91. Found: 66.40; H, 8.73. HRMS (EI) calcd for $C_{25}H_{40}O_7$ ($M^{+\cdot}$) *m/z* 452.2773, found: 452.2752. HRMS (EI) calcd for $C_{24}H_{37}O_7$ ($M[-CH_3]^{+\cdot}$) *m/z* 437.2539, found: 437.2538. MS 452 (<0.3), 437 (2), 295 (100) HRMS (EI) calcd for $C_{15}H_{19}O_6$ ($M[-C_{10}H_{21}O]^{+\cdot}$) *m/z* 295.1183; found: 295.1179. ν_{max} (film) 1654 (s), 1632 (s), 1582 (m) cm^{-1}. λ_{max} = 247, 327 (ε = 17,500, 5980).



^{1}H NMR (200 MHz, $CDCl_3$, 20°C): δ = 0.899 (3H, d, J = 5.8 Hz, CH_3-9), 1.128 (6H, s, CH_3-2, CH_3-3), 1.342, 1.360 (12H, d, J = 6.2 Hz, 4 × CH_3-17), 1.4–0.8 (8H, m, CH_2-5, CH_2-6, CH_2-7, CH-8, CH_2-10a), 1.51 (1H, m, CH_2-10-b), 3.168 (3H, s, CH_3-1), 4.460, 4.509 (1H, 1:1 confomers, 2 × d, J = 5.7 and 5.6 Hz, respectively, CH-11), 5.164, 5.177 (2H, h, J = 6.2 Hz, 2 × CH-16), 6.567 (2H, s, CH-14), 12.395, 12.486 (2H, 2 × OH). ^{13}C NMR (75 MHz, $CDCl_3$, 20°C): δ = 19.72 (CH_3-9), 21.11 (CH_2-6), 21.88, 21.99, 22.09 (2×) (4 × CH_3-17), 24.94, 25.00 (CH_3-2, CH_3-3), 25.51 (CH-11), 30.31 (CH-8), 37.76, 37.85 (CH_2-7, CH_2-10), 40.21 (CH_2-5), 49.09 (CH_3-1), 68.71 (CH-16), 74.51 (C-4), 106.09, 107.10 (2 × C-12), 132.46, 132.74 (2 × CH-14), 164.15, 164.32 (2 × C-13), 172.04, 174.49 (2 × C-15). This was followed by unreacted aldehyde **10** and a diastereomeric mixture of cyclohexenonedicarboxylate **11** (0.92 g, 25.7%) [33]. The complex polar residue tinted the gravity silica gel column bright yellow and, apart from the isolation of $Ph_3As=O$, was not further analyzed.

Deuteration of **7b.** Cycloheptatriene **7b** in $CDCl_3$ was treated with D_2O and deuterium exchange took place within 24 hours. HRMS (CI) calcd for $C_{25}H_{42}D_2NO_7$ ($MNH_4^{+\cdot}$) *m/z* 472.3232; found: 472.3254.

In Situ Condensation of 1-Methylethyl 3-Oxo-4-(triphenylarsoranylidene)butanoate **2b** *and 7-methoxy-3,7-dimethyloctanal* **10.** *Li_2CO_3 as a Base.* Racemic 7-methoxy-3,7-dimethyloctanal **10** (220 mg, 1.18 mmol) was added to a suspension of finely powdered arsonium salt **8** (635 mg, 1.20 mmol) and lithium carbonate (127 mg, 1.72 mmol) in anhyd THF (10 mL) at room temperature in the presence of TEBAC (38 mg, 0.17 mmol), and the mixture was stirred under an argon atmosphere for 40 hours, followed by 24 hours at 60°C. A solution of ether:light petroleum ether (1:1) (20 mL) was added to the reaction mixture, and the suspension was filtered over silica gel and further eluted with ether:light petroleum ether (1:1). After evaporation of the solvents, the yellow viscous residue was chromatographed on silica gel and eluted with petroleum ether, ether:petroleum ether (1:19) to give triphenylarsine (215 mg, 59.6%) followed by **7b** (175 mg, 32.3%).

Samples were taken of the reaction mixture and analyzed by liquid secondary ion mass spectrometry and found to contain reactive intermediates as described in the text. Some of the more stable intermediates were determined by high-resolution mass spectrometry, but those ions above *m/z* = 900 were beyond the capabilities of the instrument for accurate mass determination. HRMS (LSIMS) calcd for $C_{43}H_{56}AsO_7$ **14** *m/z* 759.3242; found: 759.3217; HRMS (LSIMS) **15** calcd for $C_{43}H_{56}AsO_6$ *m/z* 743.3293; found: 743.3283.

The complex polar residues tinted the gravity silica gel column bright yellow. Apart from the isolation of $Ph_3As=O$, the arsonium species that were eluted with CH_2Cl_2 were only partly characterized by ^{1}H-NMR spectroscopy. The triphenylarsonium part was evident in the aromatic region. Likewise, the aliphatic region contained broad multiplets of the 1-methylethyl and methyl groups. We were not able to separate and identify by NMR spectroscopy any of the intermediate species. However, the arsonium intermediate **14** was again identified by LSIMS in a freshly eluted sample.

Na_2CO_3 as a Base. Racemic 7-methoxy-3,7-dimethyloctanal (0.32 g, 1.72 mmol) was added to a suspension of finely powdered arsonium salt **8** (950 mg, 1.79 mmol) and sodium carbonate (190 mg, 1.79 mmol) in anhydrous THF (10 mL), and the mixture was stirred at room temperature in the presence of TEBAC (90 mg, 0.4 mmol) under an argon atmosphere for 40 hours, followed by 24 hours at 60°C. The same workup procedure was followed as mentioned earlier and gave triphenylarsine (223 mg, 55.1%), **7b** (157 mg, 38.9%), and 1-methylethyl 10-methoxy-7,10-dimethyl-3-oxo-4-dodecenoate **3b** (48 mg, 8.9%) [33].

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