Journal of Organometallic Chemistry
Elsevier Sequoia S.A., Lausanne
Printed in The Netherlands

ORGANO-GROUP VB CHEMISTRY
II. VIBRATIONAL STUDY OF SOME TERTIARY SUBSTITUTED ARYLARSINES AND ARSINE OXIDES

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(Received November 13th, 1970)

SUMMARY

The IR and Raman spectra of a series of arylarsines, $(p\text{-}XC_6H_4)_3As$ and $(m\text{-}XC_6H_4)_3As$ (X = Cl, F), and of the corresponding oxides, measured over the spectral range 4000 and 100 cm^{-1}, are reported. A complete vibrational analysis is presented.

INTRODUCTION

If they are considered as *para* disubstituted benzene derivatives, the phenyl groups of the *para* substituted phenylarsines and corresponding oxides belong to the C_{2v} symmetry class. For this class all frequencies are permitted in the Raman and all but the a_2 frequency in the infrared. Similarly, the phenyl groups of the *meta* substituted phenylarsines and corresponding oxides are of C_s symmetry, and for these compounds all frequencies are both IR and Raman active.

The assignments reported here are partly based on earlier work on disubstituted benzene derivatives[1-7]. To our knowledge, however, this paper is the first to deal with a complete vibrational assignment for monosubstituted aryl Group VB compounds. For reasons of simplicity and uniformity the numbering proposed by Varsànyi[8] for disubstituted benzene derivatives has been adopted here.

The IR and Raman frequencies of all the compounds are given both in solid and liquid state. The slight solvent shifts observed for some fundamentals are at present under study.

VIBRATIONAL SPECTRA

In Tables 1 to 8 the IR and Raman spectra of the tertiary substituted arylarsines, and corresponding oxides, are given, together with a tentative assignment.

EXPERIMENTAL

IR spectra were recorded on a Perkin–Elmer 225 grating instrument using CsI windows for the 4000 cm^{-1} to 200 cm^{-1} region, all frequencies being measured with

(*continued on p.* 235)

TABLE 1 VIBRATIONAL FREQUENCIES (cm^{-1}) AND ASSIGNMENTS FOR $(4\text{-}FC_6H_4)_3As$

IR		Raman		Assignments
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.	
	3169 w			2×1586
3087 vw	3089 m			ν(CH) 20a (a_1) and 20b (b_2)
3063 w	3064 s	3062 m	3062 m p	ν(CH) 2 (a_1)
3040 vvw	3041 m			ν(CH) 7b (b_2)
	3025 (sh)			?
		2898 w		1493 + 1392
				1586 + 1298
1894 m	1892 s			975 + 937
1762 w (br)	1762 m			937 + 823
1636 m	1641 s			823 + 810
1586 vs	1585 s[a]	1591 s	1590 s dp	ν(CC) 8a (a_1) and 8b (b_2)
1527 (sh)				823 + 704
1493 vs	1484 vs	1490 w	1497 w p	ν(CC) 19a (a_1)
1449 w	1448 m			1013 + 430
1392 m	1391 s	1392 w		ν(CC) 19b (b_2)
1335 m	1330 w			823 + 512
1298 s	1299 s			ν(CC) 14 (b_2)
1270 m	1267 m[a]	1275 w	1276 w dp	β(CH) 3 (b_2)
1231 vs	1231 vs[a]	1218 m	1235 m p	ν(CF) 13 (a_1)
1158 vs	1159 vs	1166 m	1166 m p	β(CH) 9a (a_1)
1090 s	1090 s	1089 w		β(CH) 18b (b_2)
1075 m	1075 s	1072 s	1077 s p	X sens[b] 1 (a_1)
1066 s	1067 vs	1064 (sh)		
1024 m	1026 m	1020 w	1025 w	2×512
1013 s	1012 s	1015 w		β(CH) 18a (a_1)
957 w	954 w			γ(CH) 17a (a_2)[c]
937 m	937 m			γ(CH) 5 (b_1)
886 vw				1231 − 353
823 vs	822 vs[a]	824 s	828 s dp	γ(CH) 17b (b_1)
810 s		811 vs	814 vs p	X sens[b] 6a (a_1)
762 w	763 w[a]		767 m dp	350 + 417
737 w				?
721 w				512 + 205
704 w	703 w	704 m	704 w dp	ϕ(CC) 4 (b_1)
696 (sh)	680 vw			
630 w	630 w	631 s	632 s dp	α(C–C–C) 6b (b_2)
615 vw	615 w			823 − 205
586 s	586 s	587 m	588 m p	X sens[b] 12 (a_1)
565 w	565 w			205 + 353
551 w	551 w			823 − 277
512 vs	513 vs	511 w	505 w dp	ϕ(CC) 16b (b_1)
421 s	430 s	433 w		β(CF) 9b (b_2)
	417 (sh)	413 vw		ϕ(CC) 16a (a_2)[c]
		361 m		Phenyl–As–phenyl
353 s	350 s	347 (sh)	358 m dp	stretching 7a[d]
277 m	278 s	280 m	281 m	X sens 10b (b_1)
		205 vs	207 vs p	Phenyl–As–phenyl
		182 w		bending[d]

[a] Molten. [b] Radial skeletal vibration. [c] Forbidden. [d] C_{3v} symmetry of AsX_3. Local (a_1 and e).

TABLE 2

VIBRATIONAL FREQUENCIES (cm^{-1}) AND ASSIGNMENTS FOR $(4\text{-}ClC_6H_4)_3As$

IR		Raman		Assignments
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.	
	3115 vw			2×1561
3066 w (br)	3074 m			ν(CH) 20b (b_2)
	3057 (sh)	3047 m	3052 w p	ν(CH) 2 (a_1) and 13 (a_1)
	3043 (sh)	3039 w	3040 vw dp	ν(CH) 7b (b_2)
	3022 w			$1478+1561$
		2897 w		$1577+1299$
1898 w	1902 m			$962+945$
1785 w (br)	1788 w			$821+945$
1636 w	1643 m			$821+813$
1577 m	1576 s[a]	1576 m	1582 m p	ν(CC) 8a (a_1)
1561 m	1559 m[a]		1567 w dp	ν(CC) 8b (b_2)
1478 s	1479 vs			ν(CC) 19a (a_1)
1435 w	1436 m			$1013+431$
1377 s	1386 vs		1384 w dp	ν(CC) 19b (b_2)
1341 w	1342 w			$284+1066$
1317 vw	1323 w			$821+507$
1299 m	1299 m		1302 vw dp	ν(CC) 14 (b_2)
1264 w	1250 vw[a]		1262 w dp	β(CH) 3 (b_2)
1206 w	1221 vw[a]		1211 vw	$1010+206$
1176 m	1180 m	1185 w	1179 w p	β(CH) 9a (a_1)
1092 s	1093 vs	1094 m	1096 m p	X sens 12 (a_1)
1073 (sh)	1072 (sh)			
1066 s	1065 vs	1073 vs	1074 vs p	X sens[b] 1 (a_1)
1063 (sh)			1069 (sh)	
1013 s	1010 s		1014 w	β(CH) 18a (a_1)
962 w	962 vw[a]			γ(CH) 17a (a_2)[c]
945 w	943 w			γ(CH) 5 (b_1)
	903 vw			?
841 m				$352+507$
838 (sh)				
821 s	821 (sh)[a]			ν(CH) 17b (b_1)
813 vs	810 vs[a]		811 w	
728 vs	726 s[a]	729 vs	729 vs p	X sens 6a (a_1)
717 w				2×359
702 m	701 w[a]		706 w[c] dp	ϕ(CC) 4 (b_1)
677 w	684 m			$480+206$
637 w	651 w	629 m	629 w dp	α(C–C–C) 6b (b_2)
596 w	587 w			?
557 w	546 vw			$206+352$
509 m				
507 vs	495 vs		494 w p	X sens 20a (a_1)
497 (sh)				
480 m		474 w		ϕ(C–C) 16b (b_1)
	431 m			$1478-1066$
359 m				Phenyl–As–phenyl
352 m	358 m	355 w		stretching[d]
332 m		334 m	336 w[c] p	

(*Table continued*)

TABLE 2 (*continued*)

IR		Raman		Assignments
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.	
318 w		322 w		
302 w	304 (sh)	302 w	307 w dp	β(C–Cl) 9b (b_2)
	298 w			?
284 w	288 (sh)	288 w		X sens 10b (b_1)
253 m	252 m	257 w	256 m	1066 − 813
		235 w	240 m	729 − 494
		206 w		Phenyl–As–phenyl
		185 w	181 m p	bending[d] 15
		170 w		?
		132 s		?
		99 s		X sens 11 (a_1)

[a] Molten. [b] Radial skeletal vibration. [c] Forbidden. [d] C_{3v} symmetry of AsX_3. Local (a_1 and e). [e] C_6H_6.

TABLE 3

VIBRATIONAL FREQUENCIES (cm^{-1}) AND ASSIGNMENTS FOR $(3\text{-}FC_6H_4)_3As$

IR		Raman		Assignments
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.	
		3060 (sh)	3065 w p	ν(CH) 2.20 a
3056 w	3058 s	3054 m	3056 (sh) p	7a, 20 b
3019 (sh)	3024 (sh)			1594 + 1421
		2895 w		1473 + 1421
	1935 m			2 × 967
	1864 m			895 + 967
	1791 w			2 × 895
	1769 m			1086 + 684
	1744 m			781 + 967
	1679 m			895 + 781
1594 s	1593 s[a]	1597 s	1598 m p	ν(CC) 8b (a')
1585 s	1583 s[a]			
1575 s	1574 s[a]	1579 w	1581 w p	ν(CC) 8a (a')
1519 w (br)	1521 w[a]			1000 + 521
1473 vs	1473 vs	1470 w	1470 w p	ν(CC) 19b (a')
1421 s	1421 vs			ν(CC) 19a (a')
1411 (sh)	1410 (sh)		1416 vw p	
1298 m	1299 s	1301 w	1301 w p	β(CH) 3 (a')
1262 s	1259 s	1260 m	1267 m p	ν(CC) 14 (a')
1212 vs	1209 vs	1212 m	1219 m[b] p	ν(CF) 13 (a')
	1182 (sh)			661 + 521
1160 m	1160 s	1163 s	1163 m p	β(CH) 9b (a')
	1113 vw			445 + 684
1086 s	1087 s	1086 m	1091 w p	X sens 18b (a')
1055 w	1057 m	1063 m	1063 m p	β(CH) 18a (a')
1000 s	1000 s[a]	1002 vs	1004 vs p	X sens[c] 12 (a')
	984 vw[a]		992 w	1421 − 445
967 w (br)	965 w (br)[a]			γ(CH) 5 (a'')

(*Table continued*)

TABLE 3 (*continued*)

IR		Raman			Assignments
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.		
895 m	896 m	879 w	878 (sh)		γ(CH) 17a (a'')
867 (sh)	869 (sh)	866 m	864 m	p	X sens 6b (a')
856 s	857 s				γ(CH) 17b (a'')
781 vs	779 vs[a]	779 m			γ(CH) 11 (a'')
684 vs	684 vs	687 w	688 w[b]	dp	ϕ(CC) 4 (a'')
661 m	662 vs	661 s	662 vs[b]	p	X sens[c] 1 (a')
560 w	559 s	559 m			ϕ(CC) 16a (a'')
521 s	521 vs	522 s	523 s	p	X sens 6a (a')
445 s	445 s				ϕ(CC) 16b (a'')
430 m	430 vs	428 w	433 w	p	β(CF) 15 (a')
309 m		314 m	314 w	p	Phenyl–As–phenyl stretching[d]
	303 (sh)				
293 m	294 s	299 (sh)			
286 m	286 vs	289 m	291 m	dp	
		283 (sh)			
	241 w	248 s	247 vs	p	X sens 10a (a'')
		239 (sh)			
	222 w	218 (sh)	216 (sh)		Phenyl–As–phenyl bending[d]
		211 m			
		176 (sh)			X sens 10b (a'')
		168 (sh)			
		161 vs	167 vs	dp	

[a] Molten. [b] C_6H_6. [c] Radial skeletal vibration. [d] C_{3v} symmetry of AsX_3. Local (a_1 and e).

TABLE 4

VIBRATIONAL FREQUENCIES (cm^{-1}) AND ASSIGNMENTS FOR $(3\text{-}ClC_6H_4)_3As$

IR		Raman			Assignment
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.		
	3143 w				2 × 1573
	3067 (sh)	3062 w			ν(CH) 2, 13, 20a
3053 w (br)	3054 s	3044 w	3052 w	p	and 20b
		3029 w			1464 + 1573
		2897 w			?
1945 w	1942 m				2 × 971
1875 w	1875 m				971 + 903
	1808 w (br)				2 × 903
	1786 w (br)				995 + 778
	1763 m				2 × 885
1682 w	1683 m				778 + 903
1573 m	1571 vs[a]	1572 m	1577 m	p	ν(CC) 8b (a')
1564 s	1562 vs[a]	1564 m	1569 (sh)		ν(CC) 8a (a')
1464 s	1464 vs		1459 vw		ν(CC) 19b (a')

(Table continued)

TABLE 4 (*continued*)

IR		Raman			Assignment
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.		
1405 (sh)	1405 (sh)				ν(CC) 19a (a')
1392 m	1392 vs				
1337 w	1338 w				358+995
1293 w	1295 m	1295 vw			β(CH) 3 (a')
1255 w	1255 w[a]		1264 w	p	ν(CC) 14 (a')
1207 vw	1210 vw[a]				778+431
1167 w	1168 m	1167 w	1169 w	p	β(CH) 9b (a')
1121 (sh)	1123 (sh)	1127 vw			X sens[c] 1 (a')
1103 vs	1103 vs	1108 w	1110 w	p	
1086 s	1086 s	1089 w	1090 w	p	X sens 18b (a')
1067 s	1066 s	1071 w	1071 w	p	β(CH) 18a (a')
1052 (sh)					
995 s	992 w	996 vs	996 vs	p	X sens[c] 12 (a')
971 w (br)	972 vw[a]				γ(CH) 5 (a'')
903 w	905 w				?
885 m	883 s				γ(CH) 17a (a'')
877 m					γ(CH) 17b (a'')
778 vs	777 vs[a]				γ(CH) 11 (a'')
752 s	752 s[a]	750 w	757 w		X sens 6b (a')
685 s	681 s	684 w	684 w	p	ϕ(CC) 4 (a'')
651 s	651 s	648 s	654 s	p	X sens 6a (a')
532 m		532 w	534 w[b]	p	ϕ(CC) 16a (a'')
526 w	529 m (br)				?
521 w					?
431 s	432 s	437 w	436 (sh)		ϕ(CC) 16b (a'')
422 (sh)	422 (sh)	422 m	423 s	p	X sens 7b (a')
358 m	359 m (br)	354 w	361 w[b]	p	Phenyl–As–phenyl stretching[d] 7a
350 m					
305 m	304 m	307 w	308 w[b]		β(C–Cl) 15 (a')
296 m	295 m	298 w	298 m	p	
267 w	265 w	267 m	268 w	p	?
235 w	227 w	234 m	234 s	p	X sens 10a (a'')
		214 s			Phenyl–As–phenyl bending[d] 9a
			201 s	dp	
		192 m	195 w	p	
		159 s			X sens 10b (a'')
		144 s	138 s	p	
		131 s			

[a] Molten. [b] C_6H_6. [c] Radial skeletal vibration. [d] C_{3v} symmetry of AsX_3. Local (a_1 and e).

TABLE 5

VIBRATIONAL FREQUENCIES (cm^{-1}) AND ASSIGNMENTS FOR $(4\text{-}FC_6H_4)_3AsO$

IR		Raman			Assignment
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.		
	3177 w				2×1585
	3090 w				ν(CH) 20a (a_1) and 20b (b_2)
	3070 m	3065 w	3064 m	p	ν(CH) 2 (a_1)
	3039 w	3038 vw			ν(CH) 7b (b_2)
	1900 w				1081 + 823
	1773 w				939 + 823
	1644 w				823 + 815
1585 m	1583 m		1591 m		ν(CC) 8a (a_1) and 8b (b_2)
1492 s	1493 s	1495 w	1498 w	p	ν(CC) 19a (a_1)
1396 m	1397 s				ν(CC) 19b (b_2)
1302 w	1299 s				β(CH) 3 (b_2)
1223 s	1233 vs				ν(CF) 13 (a_1)
1157 m	1159 vs	1165 w	1167 m	p	β(CH) 9a (a_1)
1081 m	1083 vs	1084 m	1084 s	p	X sens[b] 1 (a_1)
	1026 w				2×516
1009 w	1012 vw	994 m	996 m	p	β(CH) 18a (a_1)
	939 w				γ(CH) 5 (b_1)
888 (sh)	907 vs		895 m	p	ν(As=O)
882 s		880 m			
868 (sh)					
838 (sh)		829 m			γ(CH) 17b (b_1)
823 s		822 m	827 vs		
808 (sh)		815 s	816 sh		X sens[b] 6a (a_1)
723 w (br)					516 + 206
676 m	675 s		679 w[a]	dp	ϕ(CC) 4 (b_1)
626		630	630 s	dp	α(C–C–C) 6b (b_2)
	587 vw	589 w	589 m	p	X sens[b] 12 (a_1)
516 s	516 vs		523 w	dp	ϕ(CC) 16b (b_1)
508 (sh)					
419 m	420 s		416 vw	dp	β(CF) 9b (b_2)
370 s		373 w			Phenyl–As–phenyl stretching[c]
363 (sh)	369 vs	364 w	373 w[a]		
352 (sh)					
321 w	316 m	317 w	313 w	dp	X sens 10b (b_1)
300 vw					?
275 vw		273 w			?
226 vw		233 w			?
203 vw		206 m	207 vs	p	Phenyl–As–phenyl bending[c]
			184 vw		

[a] CH_2Cl_2. [b] Radial skeletal vibration. [c] C_{3v} symmetry of $YAsX_3$. Local (a_1 and e).

TABLE 6

VIBRATIONAL FREQUENCIES (cm^{-1}) AND ASSIGNMENTS FOR $(4\text{-}ClC_6H_4)_3AsO$

IR		Raman			Assignment
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.		
	3079 vw				ν(CH) 20b (b_2)
	3061 w	3059 w	3059 w	p	ν(CH) 2 (a_1) and 13 (a_1)
3036 vw		3043 w			ν(CH) 7b (b_2)
3002 vw		2897 vw			1585+1298
	1585 vw	1579 w	1582 w	p	ν(CC) 8a (a_1)
1568 m	1574 w				ν(CC) 8b (b_2)
1476 s	1480 s		1478 w		ν(CC) 19a (a_1)
1387 s	1389 m		1375 w		ν(CC) 19b (b_2)
	1364 vw				1078+ 278
1298 w	1299 vw				β(CH) 14 (b_2)
1176 w	1178 w		1186 w	p	β(CH) 9a (a_1)
1093 (sh)	1096 m	1094 (sh)	1097 m	p	X sens 12 (a_1)
1078 s	1079 vs	1084 s	1081 vs	p	X sens 1 (a_1)
1008 s	1015 s				β(CH) 18a (a_1)
948 vw	945 vw		954 vw		γ(CH) 5 (b_1)
895 s	909 s				ν(As=O)
887 vs		888 s	890 m	p	
841 m					361+ 495
832 (sh)					γ(CH) 17b (b_1)
829 (sh)					
821 (sh)					
817 s			810 m	p	
737 s		730 vs	734 vs	p	X sens 6a (a_1)
700 m					ϕ(CC) 4 (b_1)
623 w		630 m	629 m	p	α(C–C–C) 6b (b_2)
502 m (sh)	503 s		507 w	p	X sens 20a (a_1)
495 s					
482 m			480 vw	dp	ϕ(CC) 16b (b_1)
368 (sh)					Phenyl–As–phenyl
361 s	360 vs		370 m	p	stretching[a] 7a (a_1)
346 (sh)					
342 m		324 m	324 m	dp	β(C–Cl) 9b (b_2)
334 w					
278 w	276 w	280 vw			X sens 10b (b_1)
260 w					
		242 w	244 w		734 – 507
		209 w	209 w		Phenyl–As–phenyl
		181 m	183 s	p	bending[a] 15
		135 m			?

[a] C_{3v} symmetry of $YAsX_3$. Local (a_1 and e).

TABLE 7

VIBRATIONAL FREQUENCIES (cm^{-1}) AND ASSIGNMENTS FOR $(3\text{-}FC_6H_4)_3AsO$

IR		Raman			Assignment
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.		
	3059 w	3068 w	3068 w	p	ν(CH) 2, 20a, 7a
3048 w					and 20b
3008 vw		2896 vw			1583 + 1312
	1934 w (br)				?
	1868 w (br)				?
1594 m	1596 m	1599 m	1599 m	p	ν(CC) 8b (a′)
1583 s	1588 s	1582 w			ν(CC) 8a (a′)
1517 w	1518 w		1520 w		518 + 996
1473 s	1473 s		1473 w	p	ν(CC) 19b (a′)
1424 s	1427 s		1414 w	p	ν(CC) 19a (a′)
1312 m	1303 w				β(CH) 3 (a′)
1272 m					ν(CC) 14 (a′)
1264 m	1268 m	1274 w	1273 w	p	
1215 vs	1221 s	1222 m	1224 m	p	ν(CF) 13 (a′)
1166 w		1168 w			β(CH) 9b (a′)
1157 w	1160 w	1161 m	1161 m	p	
1084 s	1088 m	1092 w	1094 w	p	X sens 18b (a′)
1055 m	1063 w	1065 m	1065 m	p	β(CH) 18a (a′)
996 m	997 w	1004 vs	1004 vs	p	X sens[b] 12 (a′)
970 w (br)					1424 − 443
898 vs	870 m	904 s	904 vs	p	ν(As=O)
	863 (sh)				X sens 6b (a′)
859 s			857 m	dp	ν(CH) 17b (a″)
788 s		794 w	791 w	dp	γ(CH) 11 (a″)
732 w (br)					1594 − 859
683 vs	681 s				φ(CC) 4 (a″)
666 m	669 m	667 s	668[a] m	p	X sens[b] 1 (a′)
557 m	560 w	562 w	557 w	dp	φ(CC) 16a (a″)
518 s	521 m	519 s	524 s	p	X sens 6a (a′)
443 s	445 s				φ(CC) 16b (a″)
427 m	433 w	430 w	421 w	p	β(CF) 15 (a′)
342 s	342 s				
335 s	331 s		337 w	p	Phenyl–As–phenyl
306 w		315 w	310 s	p	stretching[c]
297 w	293 w		302 w[a]	dp	
258 w	254 w	245 s	245 m[a]	dp	X sens 10a (a″)
237 w	242 w	234 (sh)			Phenyl–As–phenyl
		217 m	220 m	p	bending[c] 9a
		183 w			?
			160 s	dp	X sens 10b (a″)
		146 m	154 (sh)		

[a] CH_2Cl_2. [b] Radial skeletal vibration. [c] C_{3v} symmetry of $YAsX_3$. Local (a_1 and e).

TABLE 8

VIBRATIONAL FREQUENCIES (cm^{-1}) AND ASSIGNMENTS FOR $(3\text{-}ClC_6H_4)_3AsO$

IR		Raman			Assignment
Perfluorocarb./Nujol	CCl_4 soln.	Solid	$CHCl_3$ soln.		
	3075 (sh)				ν(CH) 2, 13, 20a
3050 vw	3057 m	3061 m	3059 m	p	and 20b
	3022 vw				1464+1563
		2897 w			?
1572 m	1575 m	1578 m	1580 m	p	ν(CC) 8b (a')
1563 m	1568 m		1571 w	p	ν(CC) 8a (a')
	1480 vw				683+ 787
1464 s	1465 s				ν(CC) 19b (a')
	1437 vw				655+ 787
1402 m	1399 s				ν(CC) 19a (a')
1307 w	1298 w				ν(CC) 14 (a')
1262 vw					β(CH) 3 (a')
1170 w			1172 w		β(CH) 9b (a')
1127 (sh)	1123 (sh)		1127 (sh)		X sens[a] 1 (a')
1111 s	1110 s		1114 w	p	
1083 m	1085 m		1089 w		X sens 18b (a')
1070 m	1072 m		1074 m	p	β(CH) 18a (a'')
	1015 (sh)	1019 (sh)	1018 (sh)		X sens[a] 12 (a')
996 w	994 w	997 vs	997 vs	p	
917 w					?
906 (sh)					ν(As=O)
898 vs	912 vs	898 s	901 s	p	
	882 (sh)				γ(CH) 17a (a'')
787 vs					γ(CH) 11a (a'')
766 w					?
757 m					X sens 6b (a')
726 w (br)					2 × 363
683 vs	680 vs				ϕ(CC) 4 (a'')
655 s	658 s	656 s	658 s	p	X sens 6a (a')
530 s	530 m				ϕ(CC) 16a (a'')
505 w	502 vw				2 × 254
431 s	431 s	437 w			ϕ(CC) 16b (a'')
		429 w	429 m	p	X sens 7b (a')
368 s	369 s	372 w	370 w	p	Phenyl–As–phenyl
363 s					stretching[b] 7a
312 s	312 m	314 w	314 w		X sens 15 (a')
		292 m	292 w	p	[β(C–Cl)]
254 m	246 m	258 m	258 w		X sens 10a (a'')
222 w			239 m	p	
213 vw		214 m			Phenyl–As–phenyl
		209 (sh)	208 m		bending[b] 9a
		196 w			
		172 w			?
		149 vs	138 s	dp	X sens 10b (a'')
		121 s			?

[a] Radial skeletal vibration. [b] C_{3v} symmetry of $YAsX_3$. Local (a_1 and e).

an accuracy of ± 1 cm^{-1}. In the solid state the spectra were taken using perfluorocarbon in the region 4000–1300 cm^{-1} and as a nujol mull below 1300 cm^{-1}. In the liquid state, CCl_4 was used as the solvent for the IR spectra, but for some regions with strong CCl_4 absorption the solid samples were melted by heating between appropriate windows. Raman spectra were recorded on a Coderg PH1 spectrometer, the light source being an O.I.P. He/Ne laser with an output of 200 mW for the 6.328 Å line. Depolarisation measurements were made by two successive recordings with the polarisation vector of the incident light turned through 90° by means of a half wave plate. Although $CHCl_3$ was used as the principal solvent for the arsines and corresponding oxides over the region 0–4000 cm^{-1}, a supplementary spectrum for the region 0–600 cm^{-1} was also taken using C_6H_6 and CH_2Cl_2 as solvents for these respective compounds.

ACKNOWLEDGEMENT

The authors wish to thank Mr. T. Haemers and Mr. F. Persyn for the spectral measurements reported in this study.

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