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SYNTHESIS AND CRYSTAL STRUCTURE OF CHIRAL CHLOROTRIS(CARBONYLMETALLATO)TIN(IV) COMPLEXES *

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Summary

The complexes $[Cp(CO)_2Fe][Cp(CO)Ni][(CO)_4Co]SnCl$ (I) ($Cp = \eta^5\text{-}C_5H_5$) and $[Cp(CO)_3Mo][Cp(CO)_2Fe][(CO)_4Co]SnCl$ (II) were prepared by the reaction of $[Cp(CO)_2Fe][Cp(CO)Ni]SnCl_2$, or $[Cp(CO)_3Mo][Cp(CO)_2Fe]SnCl_2$ with $Co_2(CO)_8$ or $TlCo(CO)_4$. A single crystal X-ray structural determination shows I to have an almost perfect tetrahedral-geometry around the Sn atom.

Introduction

In the course of our studies of the nature of the bonds between silicon, germanium, tin and transition metals, we were interested in the chirality of Group IVB elements surrounded by transition metal atoms. Such compounds lead to the synthesis of chiral polymetallic derivatives of interest both for stereochemical studies and preparation of heteropolymetallic clusters. Several tin complexes involving three [1] and four [2] identical transition metals are known and a few are known involving different transition metals [3]. The synthesis of $[Cp(CO)_3Cr][(CO)_5Mn][(CO)_4Co]SnCl$ and $[Cp(CO)_3Cr][Cp(CO)_2Fe][(CO)_4Co]SnCl$ by Behrens et al. [3b] prompted us to publish our results on the synthesis of chiral tin complexes surrounded by transition metals.

Results and discussion

Dicobalt octacarbonyl reacted with $[Cp(CO)_2Fe][Cp(CO)Ni]SnCl_2$ or $[Cp(CO)_3Mo][Cp(CO)_2Fe]SnCl_2$ with replacement of one chlorine atom, according to eqs. 1 and 2.

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* Dedicated to Professor M.G. Voronkov on the occasion of his 60th birthday on December 6, 1981.

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$$[Cp(CO)_2Fe][Cp(CO)Ni]SnCl_2 + Co_2(CO)_8 \rightarrow [Cp(CO)_2Fe][Cp(CO)Ni][(CO)_4Co]SnCl \quad (1)$$

(I)

$$[Cp(CO)_2Fe][Cp(CO)_3Mo]SnCl_2 + Co_2(CO)_8 \rightarrow [Cp(CO)_2Fe][Cp(CO)_3Mo][(CO)_4Co]SnCl \quad (2)$$

(II)

Compounds I and II were also prepared in good yields using $TlCo(CO)_4$ instead of dicobalt octacarbonyl. The nature of the metal is important in successive substitutions at tin, as previously observed by Nesmeyanov [4]: in our case, when $[Ni(CO)Cp]_2$ was refluxed with $[Cp(CO)_2Fe][(CO)_4Co]SnCl_2$ in benzene we observed the rupture of the tin—cobalt rather than tin—chloride bond (eq. 3).

$$[Cp(CO)_2Fe][(CO)_4Co]SnCl_2 + [Ni(CO)Cp]_2 \rightarrow [Cp(CO)_2Fe][Cp(CO)Ni]SnCl_2 \quad (3)$$

(III)

Complex III can be prepared by the reaction of $[Ni(CO)Cp]_2$ with $[Cp(CO)_2Fe]SnCl_3$ [5]. In contrast, $[Ni(CO)Cp]_2$ failed to react with $[Cp(CO)_3Mo][Cp(CO)_2Fe]SnCl_2$ in refluxing benzene and the nickel dimer complex decomposed. Reaction of $[Cp(CO)_2Fe]SnCl_3$ with $Co_2(CO)_8$ in the 1 : 2 mol ratio used by Manning et al. [2b] to obtain $[Cp(CO)_2Fe][(CO)_4Co]SnCl_2$ (IV) gave the complex $[Cp(CO)_2Fe][(CO)_4Co]_2SnCl$, described recently by Behrens and his coworkers [3b], and the expected product IV was obtained using a 1 : 0.65 mol ratio.

We intend to study the substitutions reactions of these complexes and to prepare optically active tin derivatives and tin clusters.

Description of the structure of the compound $[Fe(CO)_2Cp][Ni(CO)Cp][Co(CO)_4]SnCl$ (I)

The molecular structure is illustrated in Figs. 1 and 2. The chlorine atom and the metallic groups are arranged around the tin in a tetrahedral geometry, with some distortion caused by steric hindrance: thus, the Cl—Sn—(Fe, Co and Ni) angles are significantly less than the normal value of 109.5°. The geometry around cobalt is approximately trigonal bipyramidal, with the three equatorial carbonyl groups tilted toward the tin atom: the mean Sn—Co—C(eq.) angle is 83.7°. Similar values have been reported for the germyl cobalt carbonyls $H_3GeCo(CO)_4$ [13], MePh(1-Np)$GeCo(CO)_4$ [14] and $Ph_3Ge(CO)_3CoC(Et)(OEt)$ [15] and the diphenylstannyl complex $(CO)_4CoSnPh_2Mn(CO)_5$ [16]. The nickel atom has a pseudo-trigonal geometry with tin, a carbonyl ligand and the line to the center of cyclopentadienyl ring in the same plane (Table 4). The Fe—Sn bond length, 2.544 Å, falls within the range previously found for $[CpFe(CO)_2]_2SnCl_2$ [17], 2.492 Å, $[CpFe(CO)_2]_2Sn(ONO)_2$ [18], 2.56 Å, $[CpFe(CO)_2]_2SnMe_2$ [19,18b], 2.60 Å and $[CpFe(CO)_2]_2[Mo(CO)_3Cp]SnCl$, 2.59 Å [20]. The cobalt—tin distance, 2.651 Å, is nearly the same as that reported in ref. 16. The value of 2.493 Å is, to our knowledge, the first reported Ni^0—Sn bond length [21]. The chlorine—tin distance 2.453 Å agrees well with the value

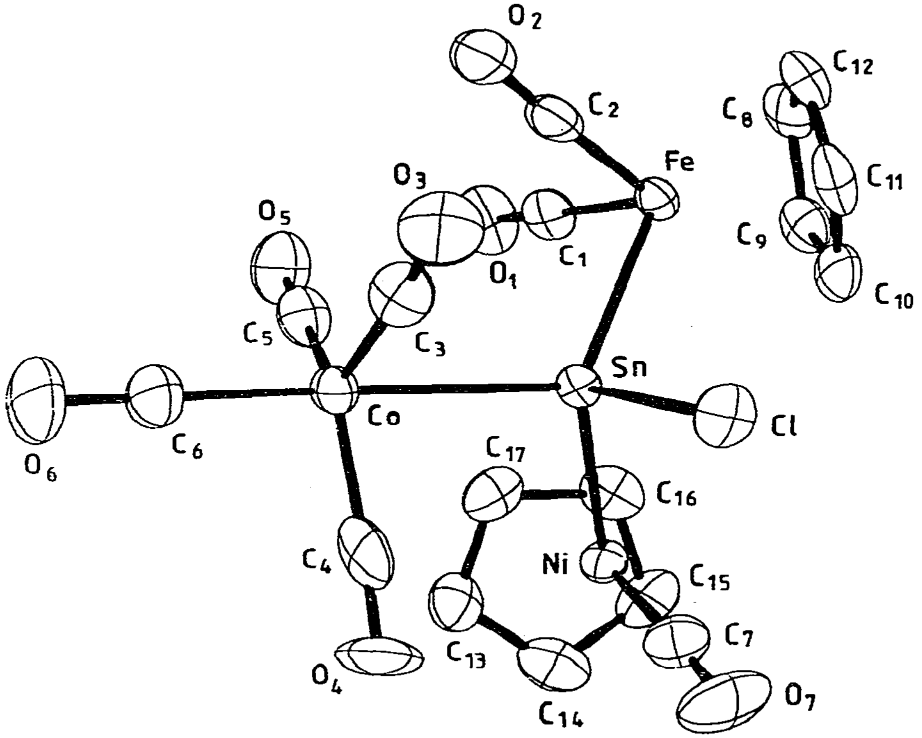

Fig. 1. ORTEP drawing of complex I.

of 2.454 Å reported by Behrens [3b] for the complex $[Fe(CO)_2Cp]_2[Co(CO)_4]$-SnCl. A larger Cl—Sn bond length (2.50 Å) was recorded for the compound $[CpFe(CO)_2]_2[Mo(CO)_3Cp]SnCl$ [20]. No other significant comparisons with compounds containing $SnCl_2$ or $SnCl_3$ moieties can be made.

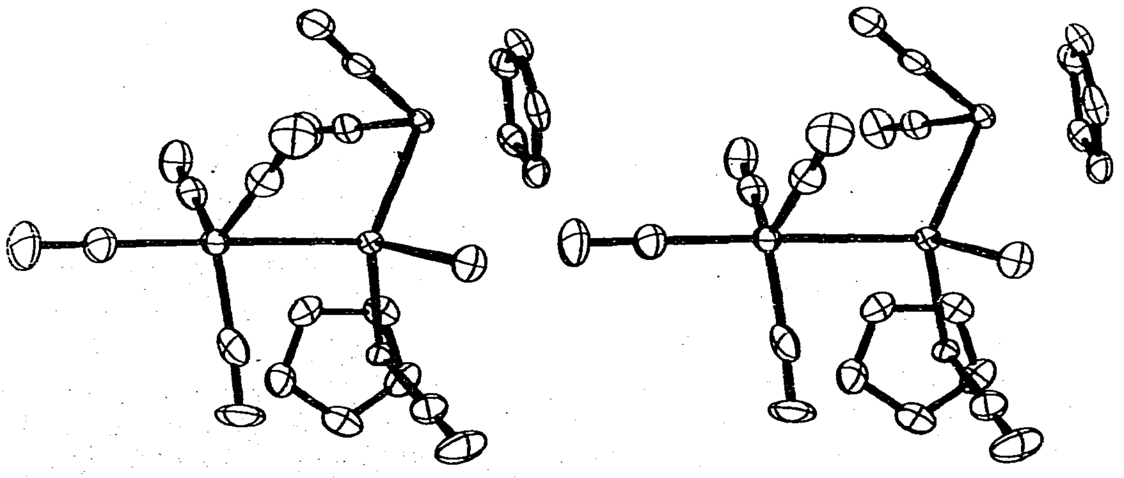

Fig. 2. Stereo-view of complex I.

Experimental

General

All manipulations were carried out under nitrogen using Schlenk techniques. All solvents were dried and degassed before use. Infrared spectra were recorded on a Perkin-Elmer 298 spectrophotometer with CaF_2 cells in hexane, toluene or tetrahydrofuran (THF). Proton NMR spectra were recorded on a Varian EM 360 instrument with TMS as internal standard. Mass spectra were recorded on a Jeol JMS-D100 spectrometer. X-ray data were collected on a Nonius CAD-4 automated diffractometer. Melting points were determined in capillaries using an oil circulating apparatus and are uncorrected.

$Co_2(CO)_8$ and $[Ni(CO)Cp]_2$ were purchased from Strem Chemicals, $[Fe(CO)_2Cp]_2$ from Pressure Chemical and $Mo(CO)_6$ from Fluka A.G. $[Cp(CO)_3Mo]Na$ [6], $Cp(CO)_3MoSnPh_3$ [7], $[Cp(CO)_3Mo][Cp(CO)_2Fe]SnCl_2$ [8], $TlCo(CO)_4$ [9], $Cp(CO)_2FeSnCl_3$ [10] and $[Cp(CO)_2Fe][Cp(CO)Ni]SnCl_2$ [5] were prepared according to published methods. $Cp(CO)_3MoSnCl_3$ was prepared as follows: HCl gas was bubbled for 30 minutes through a solution of $Cp(CO)_3MoSnPh_3$ in CCl_4 at 0°C and the solution was stirred overnight at room temperature to give $Cp(CO)_3MoSnCl_3$, which was filtered off and recrystallized from MeOH (92% yield, M.p.: 162—164°C; lit. [11] 164°C).

Preparation of $[Cp(CO)_2Fe][Cp(CO)Ni][(CO)_4Co]SnCl$ (I)

Preparation from $Co_2(CO)_8$. A solution of 248 mg (0.72 mmol) $Co_2(CO)_8$ in 10 ml THF was added to a solution of 488 mg (0.94 mmol) $[Cp(CO)_2Fe][Cp(CO)Ni]SnCl_2$ in 10 ml THF. The mixture was stirred at room temperature for 2 hours. The solvent was pumped off and the residue extracted with 30 ml hexane, filtered and cooled to —20°C to give 380 mg (0.58 mmol) (62% yield) of the title compound. M.p.: 92—96°C. $\nu(C{\equiv}O)$ (hexane) 2090s, 2045s, 2030s, 2010s, 1985m, 1980(sh) and 1970m cm^{-1}. NMR ($CDCl_3$) δ = 5.55 (s, 5 H) and 5.05 ppm (s, 5 H). Found: C, 31.03; H, 1.60; Cl, 5.44; Co, 9.02; Fe, 8.56; Ni, 8.98. Calcd for $C_{17}H_{10}ClCoFeNiO_7Sn$: C, 31.22; H, 1.54; Cl, 5.42; Co, 9.01; Fe, 8.54; Ni, 8.98%. Mass spectrum: *m/e* 626, 598, 570, 542, 514, 486, 458. ($Cp_2(CO)_6ClCoFeNiSn^+$ and successive loss of 6 CO).

Preparation from $TlCo(CO)_4$. 242 mg (0.64 mmol) $TlCo(CO)_4$ in 10 ml THF were added to 334 mg (0.64 mmol) $[Cp(CO)_2Fe][Cp(CO)Ni]SnCl_2$ dissolved in 10 ml of the same solvent. Thallium chloride precipitated out and the mixture was stirred at room temperature for 1 hour. The solvent was then pumped off and the residue extracted with toluene. Concentration of the solution, addition of pentane, and cooling to —20°C gave 200 mg (0.3 mmol) (76% yield) of black crystals. M.p.: 92—96°C; the IR and NMR spectra were identical with those of the product obtained from $Co_2(CO)_8$.

Preparation of $[Cp(CO)_3Mo][Cp(CO)_2Fe][(CO)_4Co]SnCl$ (II)

Preparation from $TlCo(CO)_4$. A solution of 220 mg (0.58 mmol) of $TlCo(CO)_4$ in 10 ml THF was added to 358 mg (0.58 mmol) $[Cp(CO)_3Mo][Cp(CO)_2Fe]SnCl_2$ in 10 ml of the same solvent. TlCl separated, and after stirring for 1 hour and filtration, the solvent was pumped off. The residue was extracted with toluene, and filtration, concentration of the extract and cooling to —20°C gave 300 mg (0.4 mmol) (69%) of II as black-brown crystals. M.p. 120—125°C (dec.). NMR (C_6D_6) δ = 4.5 (s, 5 H) and 5.0 ppm (s, 5 H). ν(C≡O) (toluene) 2090m, 2020s, 1995s, 1985(sh), 1965m, 1940m and 1915m cm^{-1}. Found: C, 30.76; H, 1.46; Co, 7.98; Fe, 7.47; Mo, 12.84. Calcd. for $C_{19}H_{10}ClCoFeMoO_9Sn$: C, 30.53; H, 1.35; Co, 7.89; Fe, 7.49; Mo, 12.84%. Mass spectrum: *m/e* 247, 219, 191, 163 ($Mo(CO)_3Cp^+$ and successive loss of 3 CO); 177, 149, 121 ($Fe(CO)_2Cp^+$ and successive loss of 2 CO); 171, 143, 115, 87 ($Co(CO)_4^+$ and successive loss of 4 CO) (plus other unidentified peaks up to 650).

Preparation from $Co_2(CO)_8$. 200 mg (0.58 mmol) $Co_2(CO)_8$ in 10 ml THF were added to 238.5 mg (0.39 mmol) $[Cp(CO)_3Mo][Cp(CO)_2Fe]SnCl_2$ in 10 ml THF and the mixture was stirred at room temperature for 1 hour. The solvent was pumped off and the residue extracted with toluene. Filtration, concentration and cooling of the extract at —20°C gave black brown crystals of II; m.p. IR, NMR and mass spectrum were identical with those of the product obtained from $TlCo(CO)_4$.

Preparation of $[Cp(CO)_2Fe][(CO)_4Co]_2SnCl$

840 mg (2.4 mmol) $Co_2(CO)_8$ in 20 ml THF were added to 528 mg (1.3 mmol) $Cp(CO)_2FeSnCl_3$ and the mixture was stirred at room temperature for 1 hour. The solvent was pumped off and the residue extracted with toluene. The extract was filtered and cooled to —20°C to give 612 mg (0.9 mmol) (70%) of black-red crystals. M.p.: 114—115°C. ν(C≡O) (toluene) 2100s, 2080vs, 2040(sh), 2020vs, 2000s and 1965w cm^{-1}. NMR (CCl_4) δ = 5.15 ppm. Found: C, 26.75; H, 0.71; Cl, 5.42. Calcd. for $C_{15}H_5ClCo_2FeO_{10}Sn$: C, 26.76; H, 0.71; Cl, 5.27%. Mass spectrum: *m/e* 646, 618, 590, 562, 534, 506, 478, 450, 422, 394, $[(Cp(CO)_2Fe][Co(CO)_4][Co(CO)_3]SnCl^+$ and successive loss of 9 CO).

Crystal structure determination

Compound I was dissolved in toluene. Subsequent dilution with hexane and cooling to —20°C gave red-black needles and a few unidentified small grey tubes. Rotation and Weissenberg photographs taken with Cu-K_α radiation gave the preliminary unit-cell parameters and also indicated that the crystals were monoclinic, with space group $P2_1/c$. A crystal of approximate dimensions 0.08 × 0.15 × 0.30 mm was sealed in a Lindeman glass capillary and was mounted with the *b* axis coincident with the φ axis of the diffractometer. Lattice constants, a = 16.159(3), b = 8.618(2), c = 16.230(4) Å and β = 109.91(2)° came from the angular settings of 25 reflections obtained at medium and high angles with graphite-monochromated Mo-K_α radiation (λ = 0.71069 Å). The unit cell volume is 2125 $Å^3$. A unit cell containing exactly four molecules of the complex ($C_{17}H_{10}ClCoFeNiO_7Sn$, Mw = 653.9) gives a calculated density of 2.043 g cm^{-3}. The instability of the crystals prevented any accurate density measurement. However, an approximate value of 2.01(5) was obtained by flotation in aqueous zinc dichloride.

A total of 2167 reflections were measured in the range $4° < 2\theta < 40°$ using the ω—θ scanning technique. The intensities of three standard reflections were monitored at intervals of 60 min, and showed no significant changes occurred during data collection. All data were used in solving the structure, but 1567 were found to have $I > 2.5\sigma(I)$ and kept in the refinement. Corrections for Lorentz

TABLE 1

FRACTIONAL ATOMIC COORDINATES FOR $[Cp(CO)_2Fe][Cp(CO)Ni][(CO)_4Co]SnCl$. ESTIMATED STANDARD DEVIATIONS IN PARENTHESES

Atom	x/a	y/b	z/c
Sn	0.23893(3)	0.56424(6)	0.52730(3)
Fe	0.30617(8)	0.33559(13)	0.62671(7)
Co	0.34463(7)	0.72929(13)	0.46722(7)
Ni	0.09528(7)	0.53026(13)	0.40656(7)
Cl	0.2113(2)	0.7554(3)	0.6269(2)
O(1)	0.3258(6)	0.1537(9)	0.4841(6)
C(1)	0.3182(7)	0.2301(11)	0.5392(7)
O(2)	0.4791(5)	0.4732(10)	0.6740(5)
C(2)	0.4088(8)	0.4217(12)	0.6536(6)
O(3)	0.4287(5)	0.8354(10)	0.6461(5)
C(3)	0.3944(7)	0.7908(11)	0.5773(8)
O(4)	0.1832(5)	0.8963(10)	0.3663(7)
C(4)	0.2440(9)	0.8273(13)	0.4059(8)
O(5)	0.4027(5)	0.4259(10)	0.4284(5)
C(5)	0.3767(7)	0.5426(14)	0.4424(6)
O(6)	0.4571(6)	0.9031(11)	0.3923(7)
C(6)	0.4139(7)	0.8389(13)	0.4222(7)
O(7)	0.0227(6)	0.8042(11)	0.4565(6)
C(7)	0.0519(7)	0.6950(15)	0.4387(7)
C(8)	0.2943(8)	0.1477(12)	0.7043(7)
C(9)	0.2099(7)	0.1851(11)	0.6434(7)
C(10)	0.1918(7)	0.3416(13)	0.6624(7)
C(11)	0.2685(9)	0.3947(13)	0.7316(7)
C(12)	0.3298(7)	0.2783(13)	0.7576(6)
C(13)	0.0997(8)	0.4722(15)	0.2803(7)
C(14)	0.0139(9)	0.4680(13)	0.2800(7)
C(15)	0.0064(7)	0.3533(14)	0.3401(8)
C(16)	0.0902(8)	0.2903(11)	0.3821(7)
C(17)	0.1485(7)	0.3681(13)	0.3455(7)

and polarization effects were applied. No correction was made for absorption ($\mu(\text{Mo-}K_\alpha) = 35.8\ \text{cm}^{-1}$).

The positions of the tin, iron, cobalt and nickel atoms were determined by direct methods, using a 1972 version of the Multan program. The remaining non-hydrogen atoms were located from two successive difference Fourier syntheses. The atomic scattering factors were taken from ref. 12. Four cycles of fullmatrix isotropic refinement gave a residual of $R = 0.044$. The 29 non-hydrogen atoms were then given anisotropic thermal parameters. The scale factor and the positional and thermal atomic parameters were refined by minimizing the function $\Sigma w(|F_0| - |F_c|)^2$, where $w = [(0.5\sigma(F_0))^2 + (0.04|F_0|)^2]^{-1}$. The final R and Rw values were 0.036 and 0.049, respectively. The error of fit was 1.33. The ratios of parameters shifts to standard deviations in the last cycle were less than 0.02. The final atomic coordinates with the associated anisotropic thermal parameters are listed in Tables 1 and 2, respectively. The geometry of the complex and the labelling scheme are shown in Fig. 1. Individual bond lengths are listed in Table 3 and important bond angles in Table 4. A list of observed and calculated structure factors can be obtained from the authors.

TABLE 2. ANISOTROPIC THERMAL PARAMETERS × 10^4. ESTIMATED STANDARD DEVIATIONS IN PARENTHESES [a]

Atom	β_{11}	β_{22}	β_{33}	β_{12}	β_{13}	β_{23}
Sn	37.4(4)	85(1)	32.3(4)	−3.1(4)	12.4(3)	−2.3(4)
Fe	45.8(7)	93(2)	33.3(6)	3.1(8)	16.8(5)	9.2(8)
Co	38.9(7)	112(2)	44.0(7)	−10.9(8)	14.1(5)	12.0(8)
Ni	34.4(6)	138(2)	35.6(6)	−4.6(8)	8.7(4)	−6.3(8)
Cl	64(1)	127(4)	58(1)	−5(2)	28(1)	−33(2)
O(1)	136(6)	140(13)	90(5)	20(7)	66(5)	−20(7)
C(1)	71(6)	88(15)	58(5)	7(7)	29(5)	8(7)
O(2)	57(4)	352(19)	69(5)	−20(8)	10(4)	63(7)
C(2)	56(6)	207(21)	43(5)	−7(8)	9(5)	40(8)
O(3)	76(5)	279(17)	63(5)	−45(7)	9(4)	−48(7)
C(3)	60(6)	115(15)	71(7)	−14(7)	25(5)	−3(9)
O(4)	54(4)	322(19)	151(8)	34(7)	9(5)	164(11)
C(4)	82(8)	179(19)	72(7)	−61(10)	33(6)	30(10)
O(5)	97(5)	212(15)	83(5)	−13(7)	56(4)	−42(7)
C(5)	70(6)	178(19)	39(5)	−32(9)	22(4)	−22(8)
O(6)	97(6)	330(20)	155(9)	−37(9)	73(6)	81(11)
C(6)	60(6)	181(18)	79(7)	−13(9)	31(5)	23(9)
O(7)	83(5)	276(18)	105(6)	78(8)	18(5)	−44(9)
C(7)	47(5)	251(25)	60(6)	−3(10)	8(5)	1(10)
C(8)	83(7)	150(18)	64(6)	12(9)	38(6)	43(9)
C(9)	71(7)	153(19)	62(6)	−34(8)	31(5)	22(9)
C(10)	61(6)	197(20)	71(7)	−13(8)	40(6)	32(9)
C(11)	107(9)	189(19)	53(6)	−8(11)	56(6)	4(9)
C(12)	80(6)	191(19)	41(5)	−9(10)	29(5)	26(9)
C(13)	69(7)	309(27)	43(5)	−19(11)	22(5)	−27(11)
C(14)	89(9)	212(21)	43(6)	−17(10)	−2(5)	−19(9)
C(15)	46(6)	237(22)	85(7)	−36(9)	15(6)	−55(11)
C(16)	84(7)	117(15)	53(5)	−16(9)	13(6)	−26(8)
C(17)	60(6)	206(20)	57(6)	12(9)	21(5)	−52(9)

[a] The thermal ellipsoid is given by $\exp[-(\beta_{11}h^2 + \beta_{22}k^2 + \beta_{33}l^2 + 2\beta_{12}hk + 2\beta_{13}hl + 2\beta_{23}kl)]$.

TABLE 3. INTERATOMIC DISTANCES (Å)

Sn—Cl	2.4528(22)	C(1)—O(1)	1.151(11)
Sn—Fe	2.5441(12)	C(2)—O(2)	1.158(11)
Sn—Co	2.6506(12)	C(3)—O(3)	1.132(11)
Sn—Ni	2.4931(11)	C(4)—O(4)	1.141(14)
		C(5)—O(5)	1.142(11)
Fe—C(1)	1.752(11)	C(6)—O(6)	1.122(12)
Fe—C(2)	1.731(12)	C(7)—O(7)	1.132(12)
Co—C(3)	1.772(12)		
Co—C(4)	1.802(15)		
Co—C(5)	1.778(12)	Fe—C(8)	2.099(9)
Co—C(6)	1.800(12)	Fe—C(9)	2.112(8)
Ni—C(7)	1.741(13)	Fe—C(10)	2.117(9)
		Fe—C(11)	2.058(9)
C(8)—C(9)	1.422(15)	Fe—C(12)	2.086(9)
C(9)—C(10)	1.435(14)	Fe—Cp(1) [a]	1.714
C(10)—C(11)	1.435(16)		
C(11)—C(12)	1.371(16)		
C(12)—C(8)	1.417(15)	Ni—C(13)	2.133(10)
C(13)—C(14)	1.385(16)	Ni—C(14)	2.097(9)
C(14)—C(15)	1.422(16)	Ni—C(15)	2.120(10)
C(15)—C(16)	1.402(15)	Ni—C(16)	2.102(9)
C(16)—C(17)	1.439(15)	Ni—C(17)	2.063(9)
C(17)—C(13)	1.407(16)	Ni—Cp(2) [a]	1.727

[a] Cp(1) and Cp(2) are the centres of the cyclopentadienyl rings.

TABLE 4

IMPORTANT BOND ANGLES (deg.)

Cl—Sn—Fe	103.70(7)	Sn—Ni—C(7)	91.7(3)
Cl—Sn—Co	99.58(6)	Sn—Ni—Cp(2)	126
Cl—Sn—Ni	105.49(6)	C(7)—Ni—Cp(2)	142
Fe—Sn—Co	117.35(4)		
Co—Sn—Ni	108.55(4)	Fe—C(1)—O(1)	176.3(9)
Ni—Sn—Fe	119.32(4)	Fe—C(2)—O(2)	176.8(8)
		Co—C(3)—O(3)	176.4(9)
C(1)—Fe—C(2)	93.7(5)	Co—C(4)—O(4)	176.0(8)
Sn—Fe—C(1)	91.7(3)	Co—C(5)—O(5)	175.6(9)
Sn—Fe—C(2)	89.6(3)	Co—C(6)—O(6)	177.6(1.1)
Cp(1)—Fe—C(1)	126	Ni—C(7)—O(7)	177.4(1.0)
Cp(1)—Fe—C(2)	126		
Cp(1)—Fe—Sn	120	C(12)—C(8)—C(9)	109.7(9)
		C(8)—C(9)—C(10)	106.3(9)
Sn—Co—C(3)	85.3(3)	C(9)—C(10)—C(11)	106.5(1.0)
Sn—Co—C(4)	83.2(3)	C(10)—C(11)—C(12)	110.3(1.0)
Sn—Co—C(5)	82.6(3)	C(11)—C(12)—C(8)	107.1(1.0)
Sn—Co—C(6)	177.8(4)	C(17)—C(13)—C(14)	106.9(1.0)
C(6)—Co—C(3)	96.9(5)	C(13)—C(14)—C(15)	109.5(1.0)
C(6)—Co—C(4)	95.7(4)	C(14)—C(15)—C(16)	108.0(1.0)
C(6)—Co—C(5)	96.5(5)	C(15)—C(16)—C(17)	106.2(1.0)
		C(16)—C(17)—C(13)	109.2(9)

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