mixture was stirred and irradiated for several days until the color changed from violet to brown. The solution was then evaporated to dryness, and the residue was extracted with CH_2Cl_2 . The solution was chromatographed over Florisil. Elution with hexane/ CH_2Cl_2 (2/1) gave a red-brown (M = Mo) or brown (M = W) band, from which the product 10 (M = Mo) or 11 (M = W) was isolated in about 23% (M = Mo) or 40% (M = W) yield. Further elution with CH_2Cl_2 gave the violet starting compound 3. Complexes 10 and 11 are soluble in common organic solvents are are recrystallized from a CH_2Cl_2 /hexane mixture.

Anal. Calcd for $C_{22}H_{16}Mo_4O_{10}S_4^{-}(10)$: C, 27.8; Mo, 40.3. Found: C, 27.8; Mo, 40.4. Complex 10 decomposed in the mass spec-

trometer giving the $[(C_5H_5)\dot{M}o(SMe)_4\dot{M}o(C_5H_5)]$ species, suggesting that some recombination took place in the spectrometer. Molar conductivity: 1.5. Anal. Calcd for $C_{17}H_{16}Mo_2O_5S_4W$ (11): C, 25.4; S, 15.9; Mo, 23.8; W, 22.8. Found: C, 24.8; S, 15.9; Mo, 21.2; W. 22.0. Molar conductivity: 1.1.

(b) Attempted Dealkylation Reactions of (3). (i) With $[\{(\eta^5-C_5H_5)Fe(Co)_{2}\}_2]$ The molybdenum complex 3 (0.8 g, 1.6×10^{-3} mol) and excess of $[\{(\eta^5-C_5H_5)Fe(CO)_{2}\}_2]$ (0.4 g) were refluxed in toluene for 24 h. Removal of the solvent in vacuo provided only ferrocene and starting complex.

(ii) With $[(\eta^5-C_5H_5)V(CO)_4]$. Reaction of 3 (0.7 g) in THF with 1 equiv of $[(\eta^5-C_5H_5)V(CO)_4]$ at 40 °C for 4 days also resulted in no reaction.

(c) Attempted Reaction of 3 with Unsaturated Molecules. Complex 3 (0.8 g, 1.6×10^{-3} mol) in tetrahydrofuran was photolyzed or heated for 60 h with 2×10^{-3} mol of hexafluorobutyne. After removal of the solvent, only starting complex was detected.

(d) Attempted Reaction of 3 with \overline{CO} . 3 was dissolved in THF and 1 atm of CO was added. The solution was stirred at 60 °C for 24 h. The starting compound was recovered and identified by IR and NMR spectra.

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Registry No. 1a, 103619-72-3; 1b, 103667-00-1; 1c (X = Cl), 103667-03-4; 1c (X = Br), 103750-97-6; 1d, 103667-04-5; 1e, 103667-05-6; 2a, 103619-73-4; 2b, 103667-01-2; 3, 103619-81-4; 5a, 103639-17-4; 5b, 103619-76-7; 5c, 103619-77-8; 6a, 103639-18-5; 6b, 103619-78-9; 7a, 103619-79-0; 7b, 103619-80-3; 8a, 81874-19-3; 8b, 81874-18-2; 9, 103728-97-8; 10, 103619-82-5; 11, 103619-83-6; $[Mo_2(CO)_4(M-SMe)_2(\eta^5-C_5H_5)_2]$, 103619-74-5; $[W_2(CO)_4(M-SMe)_2(\eta^5-C_5H_5)]$, 37131-50-3; Na[Fe(CO)_2(\eta^3-C_5H_5)], 12152-20-4; [$Fe(CO)_2(\eta^5-C_5H_5)_2$], 11117-09-2; Mo(CO)₆, 13939-06-5; W(CO)₆, 14040-11-0; MeSSMe, 624-92-0; sodium acetylide, 1066-26-8.

Supplementary Material Available: A table of anisotropic thermal parameters (1 pages); a listing of structure factor amplitudes (7 pages). Ordering information is given on any current masthead page.

Synthesis, Phosphorus-31 Shift Correlated Two-Dimensional (COSY) Nuclear Magnetic Resonance Spectra, and Structure of the Tris(trimethyl phosphite)-Substituted Phosphido-Bridged Heteronuclear Dimer $[(MeO)_3P]_2(CO)_2Ru(\mu-PPh_2)Co(CO)_2[P(OMe)_3]$

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Trimethyl phosphite reacts with the phosphido-bridged heterobinuclear complex $(CO)_4 Ru(\mu-PPh_2)Co(CO)_3$ (1), affording mono-, $[(MeO)_3P](CO)_3 Ru(\mu-PPh_2)Co(CO)_3$ (2), di-, $[(MeO)_3P]_2(CO)_2 Ru(\mu-PPh_2)Co(CO)_3$ (3a), and tri-, $[(MeO)_3P]_2(CO)_2 Ru(\mu-PPh_2)Co(CO)_2[P(OMe)_3]$ (4), substituted derivatives characterized by microanalysis and infrared and ¹H and ³¹P NMR spectroscopy. Crystals of 4 are triclinic of space group $P\overline{1}$ with a = 10.240 (2) Å, b = 11.555 (3) Å, c = 16.273 (3) Å, $\alpha = 76.24$ (2)°, $\beta = 77.97$ (2)°, $\gamma = 71.86$ (2)°, and Z = 2. The crystal structure was solved and refined to R and R_w values of 0.039 and 0.048, respectively, by using 4380 observed ($I \ge 3\sigma(I)$) reflections measured on a Syntex P2₁ diffractometer. In the heterobimetallic complex, one trimethyl phosphite ligand is located on the cobalt atom approximately trans to the Ru–Co bond and the two remaining phosphites on the ruthenium, one trans to the Ru–Co bond and the other trans to the phosphido bridge (Ru–P(1)–Co = 76.01 (3)°). An analysis of the ³¹P NMR spectrum of 4 using two–dimensional (2D) (COSY) techniques has revealed large trans (MeO)₃P–PPh₂ (² $J_{PPh_2-P(OMe)_3}$ = 177.4 Hz) and trans (MeO)₃P–P(OMe)₃ (³ $J_{P(OMe)_3-P(OMe)_3} = 80.6$ Hz) couplings and much smaller cis coupling constants.

Two fundamental aspects of the rapidly developing chemistry of heterobimetallic complexes¹⁻¹¹ are the selectivities of the two metal sites for various substrates and the degree to which one metal influences the reactivity patterns of the second center. For saturated 34-electron heterobinuclear carbonyls with strong metal-metal interactions key questions concern the sites and mechanisms (associative or dissociative) of simple substitution reac-

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tions.¹² We have previously reported¹³ that the phosphido-bridged ruthenium-cobalt compound $(CO)_4 Ru(\mu$ - $PPh_2)Co(CO)_3$ (1) reacts site specifically with 1 or 2 mol of phosphines affording mono- and disubstituted derivatives $(\hat{L})(CO)_3 Ru(\mu - PPh_2)Co(CO)_3$ (2) and $(L)_2(CO)_2 Ru$ - $(\mu$ -PPh₂)Co(CO)₃ (3), respectively. In this paper we describe the reactions of 1 with trimethyl phosphite, P- $(OMe)_3$, a ligand known for its ability to cause multiple CO substitutions in carbonyls. In addition to derivatives to types 2 and 3, a trisubstituted complex, $(L)_2(CO)_2Ru$ - $(\mu - PPh_2)Co(CO)_2(L)$ (4) (L = P(OMe)_3), has been synthesized and structurally characterized by X-ray crystallography. An analysis of the variable-temperature ³¹P NMR spectra of 4 (L = $P(OMe)_3$) using two-dimensional (2D) shift correlated (COSY) techniques has provided valuable information on the network of spin-spin-coupled ³¹P nuclei in phosphorus ligands having different stereochemical dispositions within the heterobinuclear molecule. Such data are likely to be of practical use in structural assignments for other phosphido-bridged polynuclear compounds.

Experimental Section

General Procedures. Standard Schlenk procedures were employed in manipulating air-sensitive materials. Solvents hexane, ether, THF (benzophenone ketyl), and dichloromethane (P_2O_5) were dried in the usual fashion and distilled prior to usage. Chromatographic separations used Florisil (columns) or Merck silica gel (plates).

Instrumentation. Infrared spectra were recorded on Perkin-Elmer 983, Perkin-Elmer 180, and Perkin-Elmer 225 instruments using matched sodium chloride cells of path length 0.5 mm. Mass spectra were recorded at the Centre de Mésures Physiques de l'Ouest, Université de Rennes, with a Varian MAT-311 double-focusing mass spectrometer operating at 70 eV. Routine ¹H and ³¹P{¹H} NMR spectra were measured on Bruker WP-80 spectrometers at 80 MHz for ¹H and 32.38 MHz for ³¹P. Higher field ${}^{31}P{}^{1}H$ spectra were recorded on a Bruker AM-250 system at 101.2 MHz in 10-mm tubes with CD₂Cl₂ as the solvent and lock. Homonuclear ³¹P-shift correlated 2D NMR (COSY) experiments were conducted at 101.2 (Bruker AM-250) and 121.5 MHz (Bruker AM-300) on solutions containing \sim 300 mg of complex. All ¹H shifts are referenced to Me₄Si ($\delta = 0$) and ³¹P shifts to 85% H₃PO₄.

Synthesis. $[(MeO)_3P](OC)_3Ru(\mu - PPh_2)Co(CO)_3$ (2a,b) and $[(MeO)_3P]_2(OC)_2Ru(\mu-PPh_2)Co(CO)_3$ (3a). A solution of 1¹⁴ (0.5 g; 0.92 mmol) and an excess of P(OMe)₃ (0.2 mL; 1.7 mmol) in 60 mL of THF was heated for 12 h at 45 °C. After filtration of the reaction mixture on a frit and evaporation of the solvent, the products were chromatographed on a column $(3 \times 20 \text{ cm})$ of

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Table I: Crystal Data, Intensity Collection, Reduction, and Refinement for

$[(MeO)_{3}P]_{2}(CO)_{2}Ru(\mu - PPh_{2})Co(CO)_{2}[P(OMe)_{3}]$					
formula	RuCoP ₄ O ₁₃ C ₂₅ H ₃₇				
mol wt	829.46				
cryst class	triclinic				
space group	$P\bar{1}$				
a, Å	10.240 (2)				
b, Å	11.555 (3)				
c, Å	16.273 (3)				
α , deg	76.24 (2)				
β , deg	77.97 (2)				
γ , deg	71.86 (2)				
V, Å ³	1758.2				
Ζ	2				
$ ho_{ m measd}$, g cm ⁻³	1.58				
$\rho_{\rm calcd}, {\rm g} {\rm cm}^{-3}$	1.567				
F(000)	844				
μ (Mo K α), cm ⁻¹	11.50				
cryst size, mm	$0.29 \times 0.33 \times 0.35$				
transmisn factors	0.62-0.77				
radiatn	Mo K α ($\lambda = 0.71069$ Å)				
$\max 2\theta$, deg	46.0				
scan speed, deg min ⁻¹	variable; 2.93–29.3				
scan width, deg	0.8 below $K\alpha_1$ to 0.8 above $K\alpha_2$				
stds (every 100 measurements)	109, 532				
<i>Т</i> , К	293 ± 1				
reflctns measd	4928				
reflctns obsd	4380				
R(isotropic)	0.087				
R(anisotropic)	0.053				
final R	0.039				
R _w	0.048				
w^{-1}	$3.9 - 0.0788 F_0 + 0.00153 F_0 ^2$				
max residuals, e Å ⁻³	0.78				

silica gel. Elution first with hexane afforded the red complexes 2a,b (0.65 g, 11%) and then with hexane-CH₂Cl₂ (4/1) gave the red derivative 3a (0.27 g, 39%). Final elution with dichloromethane gave only traces of 4.

2a,b: mp 96-98 °C; IR (Nujol) 2093 (m), 2026 (vs), 1989 (vs), 1939 (s) 1927 (vs), 1894 (w) cm⁻¹; ³¹P NMR (CD₂Cl₂, 193 K, 32.38

MHz), 2a, δ 177.8 (s, μ -PPh₂), 147.4 (s, P(OMe)₃), 2b, δ 181.8 (d, μ -PPh₂), 148.5 [d, P(OMe)₃, $^{2}J_{P_{\mu}-P(eq,trans)} = 173$ Hz]. 3a: mp 164–165 °C; IR (Nujol) 2069 (w), 1983 (vs), 1971 (vs), 1927 (s), 1907 (s) cm⁻¹. ³¹P NMR (CD₂Cl₂, 193 K, 32.38 MHz) $\delta 173 [d, \mu-PPh_2, {}^{2}J_{P_{\mu}-P(eq,trans)} = 188 Hz], 150 [dd, eq,trans-P-(OMe)_3], 151 [d, eq,cis-P(OMe)_3, {}^{2}J_{P(eq,cis)-P(eq,trans)} = 22 Hz]. [(MeO)_3P]_2(OC)_2Ru(\mu-PPh_2)Co(CO)_2[P(OMe)_3] (4). From$

1. A solution of 1 (0.54 g, 1 mmol) and 3 equiv of $P(OMe)_3$ (0.35 mL, 3 mmol) in THF (60 mL) was refluxed for 12 h. After filtration of the solution on a frit and evaporation of solvent, the residue was extracted with ether (30 mL). The red complex 4 crystallized from this solution (0.7 g, 85%).

From 3a. A solution of 3a (0.73 g, 1 mmol) and an excess of P(OMe)₃ (0.77 mL, 7.5 mmol) in THF (60 mL) was refluxed for 12 h. The solution was filtered on a frit, the THF was evaporated, and the red complex was extracted with ether (30 mL) from which it crystallized (0.63 g, 76%): mp 134-136 °C; IR (Nujol) 2037 (m), 1972 (br), 1921 (vs), 1876 (s) cm⁻¹; ¹H NMR (CDCl₃, 303 K, 100 MHz) δ 1.04–7.54 (m, C₆H₅), 3.72 (d), 3.40 (d), 3.38 (d, ³J_{PH} = 12 Hz); ³¹P NMR (CD₂Cl₂, 193 K, 101.2 MHz), see Table IV. Anal. Calcd for $C_{25}H_{37}O_{13}P_4CoRu$: C, 36.20; H, 4.49; P, 14.93. Found: C, 36.19; H, 4.41; P, 14.70.

X-ray Analysis: Crystallographic Data, Collection, and Reduction. Single crystals of 4 were grown from hexane/dichloromethane solutions at -5 °C. A suitable crystal of dimensions $0.29 \times 0.33 \times 0.35$ mm was glued to a glass fiber and mounted on a eucentric goniometer head for preliminary space group determination and unit cell measurement. The crystal was centered on a $\mathrm{P2}_1$ automated diffractometer and the Syntex axial photograph, autoindexing, and cell refinement routines used to determine accurate unit cell parameters. An inspection of diffraction data revealed no systematic absences and triclinic symmetry. Intensity data were collected as indicated in Table I by using Mo $K\alpha$ radiation. Intensities of two standard reflections, monitored after every 100 measurements, showed only minor fluctuations

Table II. Atomic Positional Parameters (Fractional $\times 10^4$) for $[P(OMe)_3]_2(CO)_2Ru(\mu$ -PPh₂)Co(CO)₂[P(OMe)₃]

		-	
atom	x	У	z
Ru	6691.1 (4)	5921.2 (3)	2416.2 (2)
Co	4344.7 (6)	7036.9 (6)	2504.8(4)
P(1)	6445.9 (13)	7087.4 (11)	2487.7 (8)
P(2)	8994.5 (15)	4141.0 (13)	2392.9 (10)
$\mathbf{P}(3)$	6061.9 (14)	3331.8(12)	2290.2 (8)
P(4)	3270.4(14)	8814.6 (12)	2739.5 (9)
O(1)	6986 (4)	5874 (4)	478 (2)
O(2)	6014 (5)	4304 (4)	4365 (2)
O(3)	3542(6)	7413 (5)	829 (3)
O(4)	2820 (5)	5669 (5)	3899 (3)
O(5)	9720 (4)	4900 (4)	2710(4)
$O(6)^a$	9643 (6)	2730 (5)	2683(4)
$O(6A)^b$	9406 (13)	3119 (13)	3378 (8)
$O(7)^{a}$	9940 (6)	4248 (6)	1409 (4)
$O(7A)^b$	9950 (10)	3263 (11)	1850 (7)
O(8)	7240 (4)	2537 (3)	1681(3)
O(9)	5872 (4)	2309 (3)	3115(2)
O(10)	4657(4)	3479(3)	1945 (2)
O(11)	1627 (4)	9189 (4)	2927 (4)
O(12)	3611(4)	9895 (3)	2008 (3)
O(13)	3498 (5)	9310 (4)	3531(3)
C(1)	6866 (5)	5560(4)	1197 (3)
C(2)	6261(5)	4598 (5)	3646 (3)
C(3)	3907 (6)	7232 (5)	1290 (4)
C(4)	3460 (6)	6185(5)	3361 (4)
C(5)	11210 (8)	4551 (9)	2758 (8)
C(6)	9181 (8)	2065 (8)	3555(5)
C(7)	10011 (8)	3539 (8)	852 (5)
C(8)	7098 (9)	1440 (6)	1440(5)
C(9)	4584 (7)	2404 (7)	3705 (4)
C(10)	4394 (8)	4186 (7)	1101 (4)
C(11)	782 (7)	8759 (9)	2555 (6)
C(12)	2957 (8)	11198 (6)	2023 (5)
C(13)	3431 (9)	8588 (8)	4358 (4)
C(14)	7063 (5)	7482 (5)	3343 (3)
C(15)	6825 (6)	8738 (5)	3349 (4)
C(16)	7284 (7)	9101 (6)	3971 (4)
C(17)	7950 (7)	8224(7)	4598 (4)
C(18)	8186 (8)	6964 (7)	4601 (4)
C(19)	7722 (6)	6607 (5)	3975 (4)
C(20)	7337 (5)	7933 (4)	1544 (3)
C(21)	8765 (6)	7754 (5)	1460 (4)
C(22)	9468 (7)	8327 (6)	727(4)
C(23)	8726 (8)	9094 (6)	86 (4)
C(24)	7299 (7)	9291 (5)	166 (4)
C(25)	6604 (6)	8698 (5)	904 (3)

^a Occupancy = $\frac{2}{3}$. ^b Occupancy = $\frac{1}{3}$.

(±1%). Data were corrected for Lorentz and polarization effects and then converted to unscaled $|F_{\rm o}|$ values. No absorption correction was needed.

Solution and Refinement of the Structure. All calculations were carried out on a system of programs described elsewhere¹⁵ using an IBM 4341 network in the University of Waterloo Computing Centre. Neutral atom scattering factors were taken from the ref 16; both real ($\Delta F'$) and imaginary ($\Delta F''$) components of anomalous dispersion for ruthenium and cobalt were included. The function minimized in least-squares refinement was $\sum w \cdot (\Delta |F|)^2$.

The structure was solved by standard Patterson and Fourier techniques using the full set of 4380 observed $(I \ge 3\sigma(I))$ reflections. Following location of the ruthenium and cobalt atoms in a Patterson map, subsequent Fourier syntheses revealed all non-hydrogen atom positions. Refinement of positions and isotropic temperature factors gave an R value $(R = \sum ||F_0| - |F_c|| / \sum |F_0|)$ of 0.087. Conversion to anisotropic coefficients and refinement reduced R to 0.053. At this stage a difference Fourier synthesis revealed a disorder of one trimethyl phosphite ligand with clear resolution of oxygen atoms O(6) and O(7) into two

Table III. Bond Lengths (Å) and Angles (deg) for [P(OMe)₃]₂(CO)Ru(μ-PPh₂)Co(CO)₂[P(OMe)₃]

(a) Bond Lengths Ru-C0 2.7837 (7) Ru-P(1) 2.350 (1) Ru-C1 1.920 (5) Ru-C(2) 1.934 (5) Co-P(1) 2.165 (1) Co-P(4) 2.909 (2) Co-C(3) 1.747 (6) Co-C(4) 1.768 (6) P(1)-C(14) 1.842 (5) P(2)-C(20) 1.845 (5) P(2)-O(7) 1.688 (7) P(2)-O(6A) 1.792 (14) P(2)-O(7A) 1.488 (12) P(3)-O(8) 1.589 (4) P(3)-O(9) 1.586 (4) P(3)-O(10) 1.598 (5) P(4)-O(11) 1.883 (5) P(4)-O(12) 1.578 (4) P(4)-O(13) 1.612 (5) C(1)-O(1) 1.133 (6) C(2)-O(2) 1.135 (6) C(3)-O(3) 1.162 (8) C(4)-O(4) 1.144 (8) O(5)-C(5) 1.4466 (10) O(6)-C(6) 1.502 (11) O(6A)-C(6) 1.264 (17) O(6)-C(6) 1.502 (11) O(6A)-C(6) 1.264 (17) O(7)-C(7) 1.346 (10) O(7A)-C(7) 1.571 (14) O(8)-C(8) 1.468 (8) O(9)-C(9) 1.451 (8) O(10)-C(12) 1.435 (8) O(11)-C(11) 1.410 (10) O(12)-C(12) 1.438 (7) O(13)-C(13) 1.405 (9) C(14)-C(15) 1.397 (8) C(15)-C(16) 1.394 (9) C(16)-C(17) 1.379 (10) C(17)-C(18) 1.399 (10) C(18)-C(19) 1.400 (9) C(19)-C(14) 1.380 (8) C(20)-C(21) 1.393 (9) C(21)-C(22) 1.380 (8) (10) Bond Angles Co-Ru-P(1) 48.99 (3) Co-Ru-P(2) 151.86 (4) Co-Ru-P(1) 4.99 (3) Co-Ru-P(2) 103.89 (5) C(22)-C(23) 1.387 (10) C(23)-C(24) 1.390 (11) C(24)-C(25) 1.405 (8) C(25)-C(20) 1.380 (8) (12) C(20)-C(21) 1.393 (9) C(21)-C(22) 1.395 (9) C(22)-C(23) 1.387 (10) C(23)-C(24) 1.390 (12) C(24)-C(25) 1.405 (8) C(25)-C(20) 1.380 (8) (12) (12)-Ru-C(2) 86.5 (2) P(1)-Ru-P(2) 103.89 (5) C(22)-C(23) 1.387 (10) C(23)-C(24) 1.380 (8) (12) Co-Ru-C(1) 93.2 (2) P(2)-Ru-C(1) 86.6 (2) Co-Ru-C(2) 86.5 (2) P(1)-Ru-P(2) 103.89 (5) (20)-C(21) 1.393 (9) C(22)-C(20) 1.380 (8) (13) (14)-Cu-C(3) 93.2 (2) P(2)-Ru-C(2) 94.3 (2) (20)-Cu-C(3) 93.2 (2) P(2)-Ru-C(2) 94.3 (2) (21)-Ru-C(2) 93.3 (2) P(2)-Ru-C(2) 94.3 (2) (21)-Ru-C(2) 93.3 (2) P(2)-Ru-C(2) 94.3 (2) (21)-Cu-C(3) 93.2 (2) P(2)-Ru-C(2) 94.3 (2) (21)-Cu-C(3) 93.2 (2) P(2)-Ru-C(2) 94.3 (2) (21)-C(24) (13) 21.4 (4) Ru-P(2)-O(7) 114.8 (2) Ru-Cu-C(4) 95.1 (2) P(1)-Cu-C(4) 95.2 (3) (21)-C(24) (11) 124.3 (4) P(4)-O(12)-C(14) 122.8 (4) P(2)-O(6)-C(14) 122.8 (4) P(2)-O(7)-(14) 122.8 (4) P(2)-O(14)-C(15) 117.4 (3) P(1)-C(14)-C(18) 1				
		(a) Dand	Longtha	
$ \begin{array}{c} \mathrm{Ru}-\mathrm{P}(2) & 2.7837 \ (7) & \mathrm{Ru}-\mathrm{P}(1) & 2.380 \ (1) \\ \mathrm{Ru}-\mathrm{C}(1) & 1.920 \ (5) & \mathrm{Ru}-\mathrm{C}(2) & 1.934 \ (5) \\ \mathrm{Co}-\mathrm{P}(1) & 2.165 \ (1) & \mathrm{Co}-\mathrm{P}(4) & 2.090 \ (2) \\ \mathrm{Co}-\mathrm{C}(3) & 1.747 \ (6) & \mathrm{Co}-\mathrm{C}(4) & 1.763 \ (6) \\ \mathrm{P}(1)-\mathrm{C}(14) & 1.842 \ (5) & \mathrm{P}(2)-\mathrm{C}(20) & 1.845 \ (5) \\ \mathrm{P}(2)-\mathrm{O}(7) & 1.688 \ (7) & \mathrm{P}(2)-\mathrm{O}(6) & 1.554 \ (6) \\ \mathrm{P}(2)-\mathrm{O}(7) & 1.688 \ (7) & \mathrm{P}(2)-\mathrm{O}(6) & 1.558 \ (4) \\ \mathrm{P}(3)-\mathrm{O}(9) & 1.586 \ (4) & \mathrm{P}(3)-\mathrm{O}(8) & 1.889 \ (4) \\ \mathrm{P}(3)-\mathrm{O}(9) & 1.586 \ (4) & \mathrm{P}(3)-\mathrm{O}(8) & 1.889 \ (4) \\ \mathrm{P}(4)-\mathrm{O}(13) & 1.612 \ (5) & \mathrm{C}(1)-\mathrm{O}(1) & 1.133 \ (6) \\ \mathrm{C}(2)-\mathrm{O}(2) & 1.135 \ (6) & \mathrm{C}(3)-\mathrm{O}(3) & 1.162 \ (8) \\ \mathrm{C}(4)-\mathrm{O}(4) & 1.144 \ (8) & \mathrm{O}(5)-\mathrm{C}(5) & 1.466 \ (10) \\ \mathrm{O}(6)-\mathrm{C}(6) & 1.502 \ (11) & \mathrm{O}(6A)-\mathrm{C}(6) & 1.264 \ (17) \\ \mathrm{O}(7)-\mathrm{C}(7) & 1.346 \ (10) & \mathrm{O}(7A)-\mathrm{C}(7) & 1.571 \ (14) \\ \mathrm{O}(8)-\mathrm{C}(8) & 1.468 \ (8) & \mathrm{O}(9)-\mathrm{C}(9) & 1.451 \ (8) \\ \mathrm{O}(10)-\mathrm{C}(10) & 1.452 \ (8) & \mathrm{O}(11)-\mathrm{C}(11) & 1.430 \ (9) \\ \mathrm{C}(14)-\mathrm{C}(15) & 1.397 \ (8) & \mathrm{C}(15)-\mathrm{C}(16) & 1.394 \ (9) \\ \mathrm{C}(16)-\mathrm{C}(17) & 1.379 \ (10) & \mathrm{C}(17)-\mathrm{C}(18) & 1.399 \ (10) \\ \mathrm{C}(12)-\mathrm{C}(21) & 1.393 \ (9) & \mathrm{C}(21)-\mathrm{C}(22) & 1.395 \ (9) \\ \mathrm{C}(22)-\mathrm{C}(21) & 1.393 \ (9) & \mathrm{C}(22)-\mathrm{C}(22) & 1.380 \ (8) \\ \hline \mathbf{b} \ \mathbf{b} \ \mathbf{b} \ \mathbf{b} \ \mathbf{b} \ \mathbf{b} \ \mathbf{c} \ \mathbf{b} \ \mathbf{c} \ \mathbf{b} \ \mathbf{c} \ \mathbf{c}$	~ ~~	(a) Donu	Lengths	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Ru-CO	2.7837(7)	Ru-P(1)	2.350(1)
$ \begin{array}{c} \text{Ru}-\text{C}(1) & 1.920 \ (5) & \text{Ru}-\text{C}(2) & 1.934 \ (5) \\ \text{Co}-\text{P}(1) & 2.165 \ (1) & \text{Co}-\text{P}(4) & 2.090 \ (2) \\ \text{Co}-\text{C}(3) & 1.747 \ (6) & \text{Co}-\text{C}(4) & 1.763 \ (6) \\ \text{P}(1)-\text{C}(14) & 1.842 \ (5) & \text{P}(2)-\text{O}(6) & 1.554 \ (6) \\ \text{P}(2)-\text{O}(7) & 1.688 \ (7) & \text{P}(2)-\text{O}(6) & 1.594 \ (6) \\ \text{P}(2)-\text{O}(7) & 1.688 \ (7) & \text{P}(2)-\text{O}(6) & 1.598 \ (5) \\ \text{P}(4)-\text{O}(11) & 1.583 \ (5) & \text{P}(4)-\text{O}(12) & 1.578 \ (4) \\ \text{P}(4)-\text{O}(13) & 1.612 \ (5) & \text{C}(1)-\text{O}(1) & 1.133 \ (6) \\ \text{C}(2)-\text{O}(2) & 1.135 \ (6) & \text{C}(3)-\text{O}(3) & 1.162 \ (8) \\ \text{C}(2)-\text{O}(2) & 1.135 \ (6) & \text{C}(3)-\text{O}(3) & 1.162 \ (8) \\ \text{C}(4)-\text{O}(4) & 1.144 \ (8) & \text{O}(5)-\text{C}(5) & 1.466 \ (10) \\ \text{O}(6)-\text{C}(6) & 1.502 \ (11) & \text{O}(6A)-\text{C}(6) & 1.264 \ (17) \\ \text{O}(7)-\text{C}(7) & 1.336 \ (10) & \text{O}(7A)-\text{C}(7) & 1.571 \ (14) \\ \text{O}(8)-\text{C}(8) & 1.468 \ (8) & \text{O}(9)-\text{C}(9) & 1.451 \ (8) \\ \text{O}(10)-\text{C}(10) & 1.432 \ (8) & \text{O}(11)-\text{C}(11) & 1.410 \ (10) \\ \text{O}(12)-\text{C}(12) & 1.448 \ (7) & \text{O}(13)-\text{C}(13) & 1.405 \ (9) \\ \text{C}(14)-\text{C}(15) & 1.397 \ (8) & \text{C}(15)-\text{C}(16) & 1.394 \ (9) \\ \text{C}(16)-\text{C}(17) & 1.379 \ (10) & \text{C}(17)-\text{C}(18) & 1.399 \ (10) \\ \text{C}(22)-\text{C}(21) & 1.393 \ (9) & \text{C}(22)-\text{C}(22) & 1.395 \ (9) \\ \text{C}(22)-\text{C}(21) & 1.393 \ (9) & \text{C}(22)-\text{C}(22) & 1.396 \ (8) \\ \hline \textbf{C}(20)-\text{C}(21) & 1.393 \ (9) & \text{C}(22)-\text{C}(22) & 1.396 \ (8) \\ \hline \textbf{C}(20)-\text{C}(21) & 13.32 \ (2) \ \text{P}(1)-\text{Ru}-\text{P}(2) \ 103.89 \ (5) \\ \text{P}(1)-\text{Ru}-\text{P}(3) \ 108.82 \ (23)-\text{C}(24) \ 1.390 \ (11) \\ \text{C}(24)-\text{C}(2) \ 16.3 \ (2) \ 2)(2)-\text{Ru}-\text{C}(2) \ 94.3 \ (2) \\ \text{C}(2)-\text{C}(21) \ 13.32 \ (2) \ \text{P}(1)-\text{Ru}-\text{P}(2) \ 103.89 \ (5) \\ \text{P}(1)-\text{Ru}-\text{C}(2) \ 16.3 \ (2) \ \text{P}(1)-\text{Ru}-\text{P}(2) \ 103.89 \ (5) \\ \text{P}(1)-\text{Ru}-\text{C}(2) \ 16.3 \ (2) \ \text{P}(1)-\text{C}(-1) \ 18.64 \ (4) \ 100 \ (2) \ 10.86 \ (2) \ 10.88 \ (5) \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2) \ 10.86 \ (2$	Ru - P(2)	2.255(2)	Ru-P(3)	2.301(1)
$ \begin{array}{c} \text{RL} = (1) & 1.32 & 1$	$\mathbf{P}_{\mathbf{u}} = \mathbf{C}(1)$	1 000 (5)	$\mathbf{P}_{\mathbf{u}} = \mathbf{C}(0)$	1.024(5)
$\begin{array}{c} C_{0}-P(1) & 2.165 (1) & C_{0}-P(4) & 2.090 (2) \\ C_{0}-C(3) & 1.747 (6) & C_{0}-C(4) & 1.763 (6) \\ P(1)-C(14) & 1.842 (5) & P(2)-C(20) & 1.845 (5) \\ P(2)-O(7) & 1.688 (7) & P(2)-O(6) & 1.592 (14) \\ P(2)-O(7A) & 1.488 (12) & P(3)-O(8) & 1.589 (4) \\ P(3)-O(9) & 1.586 (4) & P(3)-O(10) & 1.598 (5) \\ P(4)-O(11) & 1.583 (5) & P(4)-O(12) & 1.578 (4) \\ P(4)-O(13) & 1.612 (5) & C(1)-O(1) & 1.133 (6) \\ C(2)-O(2) & 1.135 (6) & C(3)-O(3) & 1.162 (8) \\ C(4)-O(4) & 1.144 (8) & O(5)-C(5) & 1.466 (10) \\ O(6)-C(6) & 1.502 (11) & O(6A)-C(6) & 1.264 (17) \\ O(7)-C(7) & 1.346 (10) & O(7A)-C(7) & 1.571 (14) \\ O(8)-C(8) & 1.468 (8) & O(9)-C(9) & 1.451 (8) \\ O(10)-C(10) & 1.452 (8) & O(11)-C(11) & 1.410 (10) \\ O(12)-C(12) & 1.438 (7) & O(13)-C(13) & 1.405 (9) \\ C(16)-C(17) & 1.379 (10) & C(17)-C(18) & 1.399 (10) \\ C(18)-C(19) & 1.400 (9) & C(19)-C(14) & 1.380 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.386 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.386 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.386 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.380 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.386 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.386 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.386 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.380 (8) \\ C(20)-C(21) & 1.385 (10) & C-Ru-P(2) & 151.86 (4) \\ C-Ru-C(2) & 86.5 (2) & P(1)-Ru-P(2) & 103.89 (5) \\ Co-Ru-C(2) & 86.5 (2) & P(1)-Ru-P(2) & 103.89 (5) \\ Co-Ru-C(1) & 93.2 (2) & P(2)-Ru-P(3) & 99.69 (5) \\ Co-Ru-C(2) & 95.3 (2) & P(2)-Ru-P(3) & 99.69 (5) \\ C(2)-Ru-C(1) & 93.2 (2) & P(2)-Ru-P(3) & 99.69 (5) \\ C(2)-Ru-C(2) & 91.3 (2) & P(2)-Ru-P(3) & 99.69 (5) \\ C(2)-Ru-C(2) & 91.3 (2) & P(2)-Ru-P(3) & 99.69 (5) \\ C(2)-Ru-C(1) & 93.2 (2) & P(2)-Ru-P(3) & 99.69 (5) \\ C(2)-C(23) & T1.2 (2) & RU-CO-C(3) & 99.2 (2) \\ Ru-Co-C(4) & 92.1 (2) & P(1)-Co-C(4) & 98.4 (2) \\ C(3)-Cu-C(4) & 113.8 (2) & P(1)-Co-C(4) & 98.4 (2) \\ C(3)-Cu-C(4) & 113.8 (2) & P(1)-Co-C(4) & 128.8 (2) \\ C(3)-Cu-C(4) & 113.8 (2) & P(1)-Co-C(4) & 128.8 (2) \\ C(3)-Cu-C(3) & 113.8 (2) & P(1)-C(20) - $	Ru = C(1)	1.920 (5)	Ru = C(2)	1.954 (5)
$\begin{array}{cccc} C_0-C(3) & 1.747 \ (6) & C_0-C(4) & 1.763 \ (6) \\ P(1)-C(14) & 1.842 \ (5) & P(2)-C(20) & 1.845 \ (5) \\ P(2)-O(7) & 1.688 \ (7) & P(2)-O(6A) & 1.792 \ (14) \\ P(2)-O(7A) & 1.488 \ (12) & P(3)-O(8) & 1.589 \ (4) \\ P(3)-O(9) & 1.586 \ (4) & P(3)-O(10) & 1.598 \ (5) \\ P(4)-O(11) & 1.683 \ (5) & P(4)-O(12) & 1.578 \ (4) \\ P(4)-O(13) & 1.612 \ (5) & C(1)-O(1) & 1.133 \ (6) \\ C(2)-O(2) & 1.135 \ (6) & C(3)-O(3) & 1.162 \ (8) \\ C(4)-O(4) & 1.144 \ (8) & O(5)-C(5) & 1.466 \ (10) \\ O(6)-C(6) & 1.502 \ (11) & O(6A)-C(6) & 1.264 \ (17) \\ O(7)-C(7) & 1.346 \ (10) & O(7A)-C(7) & 1.571 \ (14) \\ O(8)-C(8) & 1.468 \ (8) & O(9)-C(9) & 1.451 \ (8) \\ O(10)-C(10) & 1.452 \ (8) & O(11)-C(11) & 1.410 \ (10) \\ O(12)-C(12) & 1.448 \ (7) & O(13)-C(13) & 1.405 \ (9) \\ C(14)-C(15) & 1.397 \ (8) & C(15)-C(16) & 1.394 \ (9) \\ C(16)-C(17) & 1.379 \ (10) & C(17)-C(18) & 1.399 \ (10) \\ C(14)-C(12) & 1.430 \ (8) & C(25)-C(20) & 1.380 \ (8) \\ C(20)-C(21) & 1.393 \ (9) & C(21)-C(22) & 1.395 \ (9) \\ C(22)-C(23) & 1.387 \ (10) & C(23)-C(24) & 1.390 \ (11) \\ C(24)-C(25) & 1.405 \ (8) & C(25)-C(20) & 1.380 \ (8) \\ \hline \\ Co-Ru-P(1) & 48.99 \ (3) \ Co-Ru-P(2) & 151.86 \ (4) \\ Co-Ru-P(3) & 109.44 \ (3) \ Co-Ru-C(1) & 86.6 \ (2) \\ P(1)-Ru-C(2) & 91.3 \ (2) \ P(2)-Ru-P(2) & 103.89 \ (5) \\ P(1)-Ru-C(2) & 91.3 \ (2) \ P(2)-Ru-C(2) & 94.3 \ (2) \\ P(1)-Ru-C(2) & 91.3 \ (2) \ P(2)-Ru-C(2) & 94.3 \ (2) \\ P(1)-Ru-C(2) & 91.3 \ (2) \ P(2)-Ru-C(2) & 94.3 \ (2) \\ P(1)-Co-C(3) & 113.8 \ (2) \ P(1)-Co-C(4) & 122.8 \ (2) \\ P(1)-Co-C(3) & 113.8 \ (2) \ P(1)-Co-C(4) & 99.2 \ (2) \\ Ru-Co-P(4) & 93.2 \ (2) \ P(2)-Ru-C(2) & 94.3 \ (2) \\ P(1)-Cu-C(3) & 113.8 \ (2) \ P(1)-Co-C(4) & 122.8 \ (2) \\ P(1)-Cu-C(3) & 113.8 \ (2) \ P(1)-Co-C(4) & 99.2 \ (2) \\ Ru-Co-C(4) & 92.1 \ (2) \ P(1)-Co-C(4) & 122.8 \ (2) \\ P(1)-C(2)-C(2) & 113.8 \ (2) \ P(1)-C(2)-C(2) & 114.3 \ (2) \\ Ru-P(2)-O(6) & 113.4 \ (2) \ RU-P(2)-O(7) & 114.4 \ (2) \\ Ru-P(2)-O(6) & 113.4 \ (2) \ RU-P(2)-O(7) & 114.4 \ (2) \\ Ru-P(2)-O(6) & 113.4 \ (2) \ RU-P(2)-O(7) & 114.4 \ (2) \\ P(1)-C(2)-C(3) & 113.4 \ (2) \$	Co-P(1)	2.165(1)	Co-P(4)	2.090(2)
$ \begin{array}{c} \text{P(1)-C(14)} & 1.842 (5) & P(2)-C(2) & 1.845 (5) \\ P(2)-O(5) & 1.539 (5) & P(2)-C(6) & 1.554 (6) \\ P(2)-O(7) & 1.688 (7) & P(2)-O(6) & 1.792 (14) \\ P(2)-O(7A) & 1.488 (12) & P(3)-O(10) & 1.598 (5) \\ P(4)-O(11) & 1.583 (5) & P(4)-O(12) & 1.578 (4) \\ P(4)-O(13) & 1.612 (5) & C(1)-O(1) & 1.133 (6) \\ C(2)-O(2) & 1.135 (6) & C(3)-O(3) & 1.162 (8) \\ C(4)-O(4) & 1.144 (8) & O(5)-C(5) & 1.466 (10) \\ O(6)-C(6) & 1.502 (11) & O(6A)-C(6) & 1.264 (17) \\ O(7)-C(7) & 1.346 (10) & O(7A)-C(7) & 1.571 (14) \\ O(8)-C(8) & 1.468 (8) & O(9)-C(9) & 1.451 (8) \\ O(10)-C(10) & 1.452 (8) & O(1)-C(11) & 1.410 (10) \\ O(12)-C(12) & 1.438 (7) & O(13)-C(13) & 1.405 (9) \\ C(14)-C(17) & 1.379 (10) & C(17)-C(18) & 1.399 (10) \\ C(18)-C(19) & 1.400 (9) & C(19)-C(14) & 1.380 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.395 (9) \\ C(22)-C(22) & 1.387 (10) & C(23)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline \\ Co-Ru-P(1) & 48.99 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-P(2) & 103.89 (5) \\ C(2)-C(21) & 1.393 (2) & P(2)-Ru-P(2) & 103.89 (5) \\ C(2)-C(21) & 1.393 (2) & P(2)-Ru-P(2) & 94.3 (2) \\ P(1)-Ru-P(2) & 95.2 (2) & P(1)-Ru-P(2) & 103.89 (5) \\ C(2)-Ru-C(1) & 93.2 (2) & P(2)-Ru-P(3) & 99.69 (5) (2) \\ C(3)-Ru-C(1) & 93.2 (2) & P(2)-Ru-P(3) & 99.69 (5) (2) \\ C(3)-Ru-C(1) & 93.2 (2) & P(2)-Ru-P(3) & 99.69 (5) (2) \\ C(3)-Ru-C(1) & 93.2 (2) & P(2)-Ru-P(3) & 99.69 (5) (2) \\ C(3)-Ru-C(2) & 172.5 (2) & Ru-Co-P(1) & 25.01 (3) \\ Ru-Co-C(3) & 173.8 (2) & P(1)-Co-C(4) & 98.4 (2) \\ C(3)-Co-C(4) & 171.13 & Ru-P(1)-Co & 76.01 (3) \\ Ru-CO-C(3) & 173.8 (2) & P(1)-Co-C(4) & 98.4 (2) \\ C(3)-Co-C(4) & 117.1 (3) & Ru-P(1)-C(2) & 113.2 (2) \\ Ru-Co-C(4) & 97.1 (2) & Ru-P(2)-O(7) & 113.2 (2) \\ Ru-Co-C(4) & 97.1 (2) & Ru-P(2)-O(7) & 113.2 (2) \\ Ru-Co-C(4) & 117.1 (3) & RU-P(1)-C(2) & 123.5 (3) \\ C(1)-C(1)-C(14) & 123.5 (3) & O(5)-P(2)-O(7) & 93.7 (3) \\ O(5)-P(2)-O(7) & 113.8 (2) & P(1)-C(2)-C(2) & 123.7 (3) \\ C(4)-O(1) & 173.1 (2) & RU-P(2)-O(7) & 113.2 (2) \\ C$	$C_0 = C(3)$	1 747 (6)	$C_{0}-C(4)$	1 763 (6)
$\begin{array}{c} P(1)-C(14) & 1.542 (s) & P(2)-C(20) & 1.545 (s) \\ P(2)-O(7) & 1.688 (7) & P(2)-O(6A) & 1.792 (14) \\ P(2)-O(7A) & 1.488 (12) & P(3)-O(8) & 1.589 (4) \\ P(3)-O(9) & 1.586 (4) & P(3)-O(10) & 1.598 (5) \\ P(4)-O(11) & 1.583 (5) & P(4)-O(12) & 1.578 (4) \\ P(4)-O(13) & 1.612 (5) & C(1)-O(1) & 1.133 (6) \\ C(2)-O(2) & 1.135 (6) & C(3)-O(3) & 1.162 (8) \\ C(4)-O(4) & 1.144 (8) & O(5)-C(5) & 1.466 (10) \\ O(6)-C(6) & 1.502 (11) & O(6A)-C(6) & 1.264 (17) \\ O(7)-C(7) & 1.346 (10) & O(7A)-C(7) & 1.571 (14) \\ O(8)-C(8) & 1.468 (8) & O(9)-C(9) & 1.451 (8) \\ O(10)-C(10) & 1.452 (8) & O(11)-C(11) & 1.410 (10) \\ O(12)-C(12) & 1.448 (7) & O(13)-C(13) & 1.405 (9) \\ C(14)-C(15) & 1.397 (8) & C(15)-C(16) & 1.394 (9) \\ C(16)-C(17) & 1.379 (10) & C(17)-C(18) & 1.399 (10) \\ C(14)-C(19) & 1.400 (9) & C(19)-C(14) & 1.380 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.395 (9) \\ C(22)-C(23) & 1.387 (10) & C(23)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline \\ Co-Ru-P(1) & 48.99 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-P(2) & 153.89 (5) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(1) & 96.6 (2) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-P(3) & 98.69 (5) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(2)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 94.3 (2) \\ P(2)-Ru-C(4) & 92.1 (2) & P(1)-Co-P(4) & 99.32 (5) \\ P(1)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 17.5 (2) & Ru-CO-P(4) & 99.32 (5) \\ P(1)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(1)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(2)-O(A) & 113.1 (3) & P(1)-Co-(4) & 122.8 (2) \\ P(4)-Co-C(4) & 122.1 (2) & P(1)-Co-P(4) & 99.32 (5) \\ P(1)-C(2)-O(6) & 110.1 (1) & Ru-P(3)-O(9) & 110.4 (3) \\ Ru-P(1)-O(14) & 125.3 (2) & CO-P(4)-O(12) & 114.3 (2) \\ Ru-C0-P(4) & 95.1 (2) & RU-P(2)-O(7) & 114.8 (2) \\ Ru-C0-P(4) & 95.1 (2) & RU-P(2)-O(7) & 114.8 (2) \\ Ru-C0-P(4) & 95.1 (2) & RU-P(2)-O(7) & 114.8 (2) \\ Ru-C0-P(4) & 0(13) & P(1)-C(2)-C(2) & 120.3 (3) \\ P(2)-O(7A) & 113.9 ($		1.747 (0)		1.705 (0)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	P(1)-C(14)	1.842(5)	P(2)-C(20)	1.845 (5)
$\begin{array}{c} P(2)-O(7) & 1.688 (7) & P(2)-O(6A) & 1.792 (14) \\ P(2)-O(7A) & 1.488 (12) & P(3)-O(8) & 1.589 (4) \\ P(3)-O(9) & 1.586 (4) & P(3)-O(10) & 1.598 (5) \\ P(4)-O(11) & 1.583 (5) & P(4)-O(12) & 1.578 (4) \\ P(4)-O(13) & 1.612 (5) & C(1)-O(1) & 1.133 (6) \\ C(2)-O(2) & 1.135 (6) & C(3)-O(3) & 1.162 (8) \\ C(4)-O(4) & 1.144 (8) & O(5)-C(5) & 1.466 (10) \\ O(6)-C(6) & 1.502 (11) & O(6A)-C(6) & 1.264 (17) \\ O(7)-C(7) & 1.346 (10) & O(7A)-C(7) & 1.571 (14) \\ O(8)-C(8) & 1.468 (8) & O(9)-C(9) & 1.451 (8) \\ O(10)-C(10) & 1.452 (8) & O(11)-C(11) & 1.410 (10) \\ O(12)-C(12) & 1.448 (7) & O(13)-C(13) & 1.405 (9) \\ C(16)-C(17) & 1.379 (10) & C(17)-C(18) & 1.394 (9) \\ C(16)-C(17) & 1.379 (10) & C(17)-C(18) & 1.394 (9) \\ C(16)-C(12) & 1.439 (9) & C(23)-C(24) & 1.380 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.385 (9) \\ C(22)-C(23) & 1.387 (10) & C(23)-C(24) & 1.380 (8) \\ \hline \\ Co-Ru-P(1) & 48.99 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-C(2) & 86.5 (2) & P(1)-Ru-P(2) & 103.89 (5) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-P(3) & 98.69 (5) \\ P(2)-Ru-C(1) & 93.2 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(1)-Ru-C(2) & 172.5 (2) & Ru-Co-P(4) & 99.32 (5) \\ P(1)-Co-C(3) & 113.8 (2) & P(1)-Co-P(4) & 99.32 (5) \\ P(1)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 97.6 (2) & P(4)-Co-C(4) & 98.4 (2) \\ Co-P(4)-O(14) & 127.1 (2) & Ru-P(1)-C(20) & 113.2 (2) \\ Ru-P(2)-O(6) & 110.7 (3) & O(5)-P(2)-O(7) & 93.7 (3) \\ O(5)-P(2)-O(7) & 96.0 (3) & O(5)-P(2)-O(7) & 93.7 (3) \\ O(5)-P(2)-O(7) & 96.0 (3) & O(5)-P(2)-O(7) & 93.7 (3) \\ O(5)-P(2)-O(7) & 113.9 (5) & O(6A)-P(2)-O(7) & 93.7 (3) \\ O(5)-P(2)-O(7) & 113.9 (5) & O(6A)-P(2)-O(7) & 93.7 (3) \\ O(5)-P(2)-O(7) & 113.9 (5) & O(6A)-P(2)-O(7) & 113.2 (2) \\ Ru-P(3)-O(8) & 110.1 (1) & Ru-P(3)-O(9) & 119.1 (1) \\ Ru-P(3)-O(8) & 110.1 (1) & Ru-P(3)-O(9) & 119.1 (1) \\ Ru-P(3)-O(8) & 110.1 (1) & Ru-P(3)-O(9) & 119.1 (1) \\ Ru-P(3)-O(6) & 120.4 (4) & P(2)-O(7)-C(12) & 123.5 (4) \\ P(2)-O(7A)-C(7) & 123.4 (4) & P$	P(2) = O(5)	1.539(5)	P(2) = O(6)	1.554 (6)
$\begin{array}{c} P(2) - O(7) & 1.688 (12) & P(2) - O(6A) & 1.589 (4) \\ P(3) - O(9) & 1.586 (4) & P(3) - O(10) & 1.598 (5) \\ P(4) - O(11) & 1.538 (5) & P(4) - O(12) & 1.578 (4) \\ P(4) - O(13) & 1.612 (5) & C(1) - O(1) & 1.133 (6) \\ C(2) - O(2) & 1.135 (6) & C(3) - O(3) & 1.162 (8) \\ C(4) - O(4) & 1.144 (8) & O(5) - C(5) & 1.466 (10) \\ O(6) - C(6) & 1.502 (11) & O(6A) - C(6) & 1.264 (17) \\ O(7) - C(7) & 1.346 (10) & O(7A) - C(7) & 1.571 (14) \\ O(8) - C(8) & 1.468 (8) & O(9) - C(9) & 1.451 (8) \\ O(10) - C(10) & 1.452 (8) & O(11) - C(11) & 1.410 (10) \\ O(12) - C(12) & 1.448 (7) & O(13) - C(13) & 1.405 (9) \\ C(16) - C(17) & 1.379 (10) & C(17) - C(18) & 1.399 (10) \\ C(18) - C(19) & 1.400 (9) & C(19) - C(14) & 1.380 (8) \\ C(20) - C(21) & 1.393 (9) & C(21) - C(22) & 1.395 (9) \\ C(22) - C(23) & 1.387 (10) & C(23) - C(24) & 1.390 (11) \\ C(24) - C(25) & 1.405 (8) & C(25) - C(20) & 1.380 (8) \\ \hline \\ \hline \\ Co-Ru - P(1) & 48.99 (3) & Co-Ru - P(2) & 151.86 (4) \\ Co-Ru - P(3) & 109.44 (3) & Co-Ru - C(1) & 86.6 (2) \\ P(1) - Ru - P(3) & 109.44 (3) & Co-Ru - C(1) & 86.3 (2) \\ P(1) - Ru - C(2) & 91.3 (2) & P(2) - Ru - P(3) & 98.69 (5) \\ P(2) - Ru - C(1) & 90.1 (2) & P(3) - Ru - C(2) & 94.3 (2) \\ P(2) - Ru - C(1) & 90.1 (2) & P(3) - Ru - C(2) & 94.3 (2) \\ P(2) - Ru - C(1) & 90.1 (2) & P(3) - Ru - C(2) & 94.3 (2) \\ P(2) - Ru - C(1) & 90.1 (2) & P(3) - Ru - C(2) & 94.3 (2) \\ P(4) - Co - C(3) & 113.8 (2) & P(1) - Co - P(4) & 99.32 (5) \\ P(1) - Co - C(4) & 113.8 (2) & P(1) - Co - P(4) & 99.32 (5) \\ P(1) - Cu - C(3) & 97.6 (2) & P(4) - Co - C(4) & 98.4 (2) \\ C(3) - Co - C(4) & 112.1 (2) & Ru - P(2) - O(7) & 114.8 (2) \\ C(3) - Co - C(4) & 112.1 (2) & Ru - P(1) - C(2) & 114.3 (2) \\ P(4) - O(-C(3) & 97.6 (2) & P(4) - Co - C(4) & 98.4 (2) \\ C(3) - Co - C(4) & 112.1 (2) & Ru - P(2) - O(7) & 114.8 (2) \\ C(3) - C(2) - O(7) & 113.9 (3) & O(6) - P(2) - O(7) & 93.7 (3) \\ O(5) - P(2) - O(6) & 112.4 (4) & Ru - P(2) - O(7) & 114.8 (2) \\ C(5) - P(4) - O(13) & 121.7 (2) & O(11) - P(4) - O(12) & 114.3 (2) \\ C(5) - P(4) - O(13) & 121.7 (2) & O(11) - P(4) - O(12) & 11$	$\mathbf{D}(0) = \mathbf{O}(7)$	1 (00 (7)	$\mathbf{D}(0) = \mathbf{O}(0)$	1 700 (14)
$\begin{array}{c} P(3)-O(7A) & 1.488 (12) & P(3)-O(8) & 1.589 (4) \\ P(3)-O(9) & 1.586 (4) & P(3)-O(10) & 1.598 (5) \\ P(4)-O(11) & 1.583 (5) & P(4)-O(12) & 1.578 (4) \\ P(4)-O(13) & 1.612 (5) & C(1)-O(1) & 1.133 (6) \\ C(2)-O(2) & 1.135 (6) & C(3)-O(3) & 1.162 (8) \\ C(4)-O(4) & 1.144 (8) & O(5)-C(5) & 1.466 (10) \\ O(6)-C(6) & 1.502 (11) & O(6A)-C(6) & 1.264 (17) \\ O(7)-C(7) & 1.346 (10) & O(7A)-C(7) & 1.571 (14) \\ O(8)-C(8) & 1.468 (8) & O(9)-C(9) & 1.451 (8) \\ O(10)-C(10) & 1.452 (8) & O(11)-C(11) & 1.410 (10) \\ O(12)-C(12) & 1.448 (7) & O(13)-C(13) & 1.405 (9) \\ C(14)-C(15) & 1.397 (8) & C(15)-C(16) & 1.394 (9) \\ C(16)-C(17) & 1.379 (10) & C(17)-C(18) & 1.399 (10) \\ C(18)-C(19) & 1.400 (9) & C(19)-C(14) & 1.380 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.335 (9) \\ C(22)-C(23) & 1.387 (10) & C(23)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \end{array}$ $\begin{array}{c} (b) Bond Angles \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-P(1) & 153.86 (4) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-C(1) & 86.6 (2) \\ P(1)-Ru-P(3) & 158.27 (4) & P(1)-Ru-C(2) & 94.3 (2) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(2) & 94.5 (2) \\ C(1)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 94.5 (2) \\ C(1)-Ru-C(2) & 172.5 (2) & Ru-Co-P(4) & 99.32 (5) \\ P(2)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 99.2 (2) \\ C(3)-Co-C(4) & 117.1 (3) & Ru-P(1)-C(20) & 114.3 (2) \\ C(3)-Co-C(4) & 117.1 (3) & Ru-P(1)-C(20) & 114.3 (2) \\ Co-P(1)-C(14) & 125.3 (2) & Co-P(1)-C(20) & 120.3 (2) \\ Ru-P(2)-O(6) & 110.7 (3) & O(5)-P(2)-O(7A) & 94.6 (6) \\ 10.6)-P(2)-O(7A) & 113.9 (5) & O(6A)-P(2)-O(7A) & 128.7 (5) \\ O(5)-P(2)-O(6) & 110.7 (3) & O(5)-P(2)-O(7A) & 94.6 (6) \\ 10.6)-P(2)-O(7A) & 113.9 (5) & O(6A)-P(2)-O(7A) & 94.7 (6) \\ 10.6)-P(2)-O(6A) & 112.4 (4) & Ru-P(2)-O(7A) & 128.7 (3) \\ O(5)-P(2)-O(6A) & 112.4 (4) & Ru-P(2)-O(7A) & 93.7 (3) \\ O(5)-P(2)-O(6A) & 110.4 (2) & O(9)-P(3)-O(10) & 97.3 (2) \\ O(5)-P(2)-O(6A) & 110.4 (4) & P(2)-O(7)-C(18) & 113.7 (4) \\ O(1)-C(10) & 179.1 (2) & Ru-C(2)-O(2) & 177.4 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(12$	P(2) = O(7)	1.000 (1)	P(2) = O(6A)	1.792 (14)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	P(2) - O(7A)	1.488(12)	P(3) - O(8)	1.589(4)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	P(3) = O(0)	1 586 (4)	P(3) = O(10)	1 508 (5)
$\begin{array}{c} P(4) - O(11) & 1.583 (5) & P(4) - O(12) & 1.578 (4) \\ P(4) - O(13) & 1.612 (5) & C(1) - O(1) & 1.133 (6) \\ C(2) - O(2) & 1.135 (6) & C(3) - O(3) & 1.162 (8) \\ C(4) - O(4) & 1.144 (8) & O(5) - C(5) & 1.466 (10) \\ O(6) - C(6) & 1.502 (11) & O(6A) - C(6) & 1.264 (17) \\ O(7) - C(7) & 1.346 (10) & O(7A) - C(7) & 1.571 (14) \\ O(8) - C(8) & 1.468 (8) & O(9) - C(9) & 1.451 (8) \\ O(10) - C(10) & 1.452 (8) & O(11) - C(11) & 1.410 (10) \\ O(12) - C(12) & 1.448 (7) & O(13) - C(16) & 1.394 (9) \\ C(14) - C(15) & 1.397 (8) & C(15) - C(16) & 1.394 (9) \\ C(16) - C(17) & 1.379 (10) & C(17) - C(18) & 1.395 (19) \\ C(18) - C(19) & 1.400 (9) & C(19) - C(14) & 1.380 (8) \\ C(20) - C(21) & 1.393 (9) & C(21) - C(22) & 1.395 (9) \\ C(22) - C(23) & 1.387 (10) & C(23) - C(24) & 1.390 (11) \\ C(24) - C(25) & 1.405 (8) & C(25) - C(20) & 1.380 (8) \\ \hline \\ Co-Ru - P(1) & 48.99 (3) & Co-Ru - P(2) & 151.86 (4) \\ Co-Ru - P(3) & 109.44 (3) & Co-Ru - P(1) & 151.86 (4) \\ Co-Ru - C(2) & 86.5 (2) & P(1) - Ru - P(2) & 103.89 (5) \\ P(1) - Ru - C(2) & 91.3 (2) & P(2) - Ru - C(2) & 94.3 (2) \\ P(1) - Ru - C(2) & 91.3 (2) & P(2) - Ru - C(2) & 94.3 (2) \\ P(1) - Ru - C(2) & 91.3 (2) & P(2) - Ru - C(2) & 94.3 (2) \\ P(1) - Ru - C(1) & 90.1 (2) & P(3) - Ru - C(2) & 94.3 (2) \\ P(1) - Cu - C(3) & 173.8 (2) & P(1) - Co - C(4) & 99.2 (5) \\ P(1) - Cu - C(3) & 97.6 (2) & P(4) - Co - C(4) & 99.3 (2) \\ P(4) - Co - C(3) & 97.6 (2) & P(4) - Co - C(4) & 99.3 (2) \\ P(4) - Co - C(3) & 97.6 (2) & P(4) - Co - C(4) & 99.3 (2) \\ P(4) - Cu - C(3) & 97.6 (2) & P(4) - Cu - 11 & 14.3 (2) \\ C(3) - P(2) - O(6) & 112.4 (4) & Ru - P(2) - O(7) & 114.8 (2) \\ Ru - P(2) - O(6) & 112.4 (2) & Ru - P(2) - O(7) & 114.8 (2) \\ Ru - P(2) - O(6) & 112.4 (2) & Ru - P(2) - O(7) & 114.8 (2) \\ Ru - P(3) - O(1) & 121.9 (1) & O(5) - P(2) - O(7) & 93.7 (3) \\ O(5) - P(2) - O(7) & 96.0 (3) & O(5) - P(2) - O(7) & 93.7 (3) \\ O(5) - P(2) - O(7) & 112.9 (4) & C(20) - C(20) & 114.3 (2) \\ Co - P(4) - O(11) & 112.9 (2) & Co - P(4) - O(12) & 114.3 (2) \\ C(2) - C(2) - C(2) & 112.9 (4) & P(3) - O(10) & 97.4 (2) \\ C$	$\Gamma(3) = O(9)$	1.000 (4)	r(3)=0(10)	1.030 (0)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	P(4) - O(11)	1.583(5)	P(4) - O(12)	1.578 (4)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	P(4) = O(13)	1.612(5)	C(1) = O(1)	1 133 (6)
$\begin{array}{c} C(2) - O(2) & 1.138 (b) & C(3) - O(3) & 1.162 (8) \\ C(4) - O(4) & 1.144 (8) & O(5) - C(5) & 1.466 (10) \\ O(7) - C(7) & 1.346 (10) & O(7A) - C(7) & 1.571 (14) \\ O(8) - C(8) & 1.468 (8) & O(9) - C(9) & 1.451 (8) \\ O(10) - C(10) & 1.452 (8) & O(11) - C(11) & 1.410 (10) \\ O(12) - C(12) & 1.448 (7) & O(13) - C(13) & 1.405 (9) \\ C(14) - C(15) & 1.397 (8) & C(15) - C(16) & 1.394 (9) \\ C(16) - C(17) & 1.379 (10) & C(17) - C(18) & 1.399 (10) \\ C(18) - C(19) & 1.400 (9) & C(19) - C(14) & 1.380 (8) \\ C(20) - C(21) & 1.393 (9) & C(21) - C(22) & 1.395 (9) \\ C(22) - C(23) & 1.387 (10) & C(23) - C(24) & 1.390 (11) \\ C(24) - C(25) & 1.405 (8) & C(25) - C(20) & 1.380 (8) \\ \hline \\ C(20) - C(21) & 1.393 (9) & C(21) - C(22) & 1.380 (8) \\ \hline \\ C(20) - C(21) & 1.393 (9) & C(21) - C(22) & 1.390 (11) \\ C(24) - C(25) & 1.405 (8) & Co - Ru - P(2) & 151.86 (4) \\ Co - Ru - P(3) & 109.44 (3) & Co - Ru - C(1) & 86.6 (2) \\ P(1) - Ru - P(3) & 158.27 (4) P(1) - Ru - C(1) & 86.3 (2) \\ P(1) - Ru - C(2) & 91.3 (2) P(2) - Ru - P(3) & 98.69 (5) \\ P(2) - Ru - C(1) & 90.1 (2) P(3) - Ru - C(2) & 94.3 (2) \\ P(2) - Ru - C(1) & 90.1 (2) P(3) - Ru - C(2) & 94.3 (2) \\ P(2) - Ru - C(1) & 90.1 (2) P(3) - Ru - C(2) & 94.3 (2) \\ P(1) - Co - C(3) & 113.8 (2) P(1) - Co - P(1) & 55.01 (3) \\ Ru - Co - P(4) & 153.50 (4) Ru - Co - P(1) & 55.01 (3) \\ Ru - P(1) - C(14) & 121.7 (2) Ru - P(1) - C(20) & 114.3 (2) \\ Co - P(1) - C(14) & 125.3 (2) C - P(1) - C(20) & 120.3 (2) \\ C(14) - P(1) - C(20) & 99.7 (2) Ru - P(2) - O(7) & 134.8 (2) \\ Ru - P(2) - O(6A) & 112.4 (4) Ru - P(2) - O(7A) & 94.0 (6) \\ Ru - P(3) - O(10) & 121.9 (1) O(8) - P(3) - O(1) & 97.3 (2) \\ Co - P(4) - O(13) & 21.7 (2) (R11) - P(4) - O(12) & 114.2 (23) \\ Co - P(4) - O(13) & 121.7 (2) (R11) - P(4) - O(12) & 114.3 (2) \\ Co - P(4) - O(13) & 121.7 (2) O(11) - P(4) - O(12) & 114.2 (23) \\ Co - P(4) - O(13) & 121.7 (2) O(11) - P(4) - O(12) & 104.1 (2) \\ Co - P(4) - O(13) & 120.3 (3) P(3) - O(10) & 97.3 (2) \\ Co - P(4) - O(13) & 120.3 (4) P(4) - O(12) - C(14) & 120.3 (4) \\ P(1) - C(14) - C(15) & 117.4 (3) P(1$		1.012 (0)		
$\begin{array}{cccc} C(4)-O(4) & 1.144 (8) & O(5)-C(5) & 1.466 (10) \\ O(6)-C(6) & 1.502 (11) & O(6A)-C(6) & 1.264 (17) \\ O(7)-C(7) & 1.346 (10) & O(7A)-C(7) & 1.571 (14) \\ O(8)-C(8) & 1.468 (8) & O(9)-C(9) & 1.451 (8) \\ O(10)-C(10) & 1.452 (8) & O(11)-C(11) & 1.410 (10) \\ O(12)-C(12) & 1.448 (7) & O(13)-C(13) & 1.405 (9) \\ C(14)-C(15) & 1.397 (8) & C(15)-C(16) & 1.394 (9) \\ C(16)-C(17) & 1.379 (10) & C(17)-C(18) & 1.399 (10) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.385 (9) \\ C(22)-C(23) & 1.387 (10) & C(23)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline \\ Co-Ru-P(1) & 48.99 (3) & Co-Ru-P(2) & 151.86 (4; Co-Ru-P(3) & 109.44 (3) & Co-Ru-C(1) & 86.6 (2) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-P(2) & 151.86 (4; Co-Ru-P(3) & 109.44 (3) & Co-Ru-C(1) & 86.6 (2) \\ Co-Ru-C(2) & 86.5 (2) & P(1)-Ru-C(2) & 98.69 (5) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(2) & 98.69 (5) \\ P(2)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 89.5 (2) \\ C(1)-Ru-C(2) & 172.5 (2) & Ru-Co-P(1) & 55.01 (3) \\ Ru-Co-P(4) & 153.50 (4) & Ru-Co-C(3) & 99.2 (2) \\ Ru-Co-C(4) & 92.1 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 97.6 (2) & P(4)-Co-C(4) & 98.4 (2) \\ C(3)-Co-C(4) & 117.1 (3) & Ru-P(1)-C(2) & 114.3 (2) \\ Co-P(1)-C(14) & 127.3 (2) & Co-P(1)-C(20) & 114.3 (2) \\ Co-P(1)-C(14) & 125.3 (2) & Co-P(1)-C(20) & 114.3 (2) \\ Co-P(1)-C(14) & 125.4 (2) & Ru-P(2)-O(7) & 114.8 (2) \\ Ru-P(2)-O(6) & 123.4 (2) & Ru-P(2)-O(7) & 114.8 (2) \\ Ru-P(2)-O(6) & 112.4 (4) & Ru-P(2)-O(7) & 114.8 (2) \\ Ru-P(2)-O(6) & 112.4 (4) & Ru-P(2)-O(7) & 114.8 (2) \\ Ru-P(2)-O(6) & 112.4 (4) & Ru-P(2)-O(7) & 93.7 (3) \\ O(5)-P(2)-O(7) & 113.9 (5) & O(6A)-P(2)-O(7A) & 94.0 (6) \\ Ru-P(3)-O(10) & 121.9 (1) & O(8)-P(3)-O(10) & 97.3 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(12) & 114.2 (2) \\ O(5)-P(2)-O(7A) & 113.9 (5) & O(6A)-P(2)-O(7A) & 94.0 (6) \\ Ru-P(3)-O(10) & 121.9 (1) & O(1)-C(10) & 173.5 (4) \\ P(2)-O(6A)-C(5) & 122.4 (4) & P(2)-O(7)-C(7) & 123.5 (4) \\ P(2)-O(6A)-C(6) & 120.4 (4) & P(2)-O(7)-C(7) & 123.5 (4) \\ P(2)-O(6A)-C(6) & 120.4 (4) & P(2)-O(7)-C(22) & 120.5 (3) \\ P(4)-$	C(2) - O(2)	1.135 (6)	C(3) - O(3)	1.162 (8)
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	C(4) - O(4)	1.144(8)	O(5) - C(5)	1.466(10)
$\begin{array}{c} 0(7)-C(1) & 1.346 (10) & 0(7A)-C(7) & 1.529 (17) \\ 0(8)-C(8) & 1.486 (8) & 0(9)-C(9) & 1.451 (8) \\ 0(10)-C(10) & 1.452 (8) & 0(11)-C(11) & 1.410 (10) \\ 0(12)-C(12) & 1.448 (7) & 0(13)-C(13) & 1.405 (9) \\ C(14)-C(15) & 1.397 (8) & C(15)-C(16) & 1.394 (9) \\ C(16)-C(17) & 1.379 (10) & C(17)-C(18) & 1.399 (10) \\ C(20)-C(21) & 1.383 (9) & C(21)-C(22) & 1.385 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.385 (8) \\ C(20)-C(21) & 1.393 (9) & C(22)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline \\ Co-Ru-P(1) & 48.99 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-C(1) & 86.6 (2) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-P(2) & 103.89 (5) \\ P(1)-Ru-P(3) & 158.27 (4) & P(1)-Ru-C(2) & 98.69 (5) \\ P(2)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 98.69 (5) \\ P(2)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 98.69 (5) \\ P(2)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 89.5 (2) \\ C(1)-Ru-C(2) & 172.5 (2) & Ru-Co-P(1) & 55.01 (3) \\ Ru-Co-P(4) & 153.50 (4) & Ru-Co-C(3) & 99.2 (2) \\ Ru-Co-C(4) & 92.1 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 97.6 (2) & P(4)-Co-C(4) & 98.4 (2) \\ C(3)-Co-C(4) & 117.1 (3) & Ru-P(1)-C(20) & 114.3 (2) \\ Co-P(1)-C(14) & 125.3 (2) & Co-P(1)-C(20) & 114.3 (2) \\ Co-P(1)-C(14) & 125.3 (2) & Co-P(1)-C(20) & 114.3 (2) \\ Co-P(1)-C(14) & 125.3 (2) & Co-P(1)-C(20) & 114.3 (2) \\ Co-P(1)-C(14) & 125.3 (2) & Co-P(1)-C(20) & 120.3 (2) \\ C(14)-P(1)-C(20) & 99.7 (2) & Ru-P(2)-O(7) & 114.8 (2) \\ Ru-P(2)-O(6) & 123.4 (2) & Ru-P(2)-O(7) & 114.8 (2) \\ Ru-P(2)-O(6) & 112.4 (4) & Ru-P(2)-O(7) & 114.8 (2) \\ Ru-P(2)-O(6) & 112.4 (4) & Ru-P(2)-O(7) & 113.2 (2) \\ Co-P(4)-O(11) & 112.4 (2) & Co-P(4)-O(12) & 114.2 (2) \\ Co-P(4)-O(11) & 112.4 (2) & Co-P(4)-O(12) & 114.2 (2) \\ Co-P(4)-O(11) & 112.4 (2) & Co-P(4)-O(12) & 114.2 (2) \\ Co-P(4)-O(11) & 112.4 (3) & P(1)-C(10) & 17.3 (3) \\ P(2)-O(7A)-C(7) & 122.1 (4) & P(3)-O(8)-C(16) & 120.3 (3) \\ P(2)-O(7A)-C(7) & 122.1 (4) & P(3)-O(8)-C(16) & 120.4 (3) \\ P(2)-O(10)-C(11) & 120.3 (4) \\ P(1)-C(14)-C(15) & 117.4 (3) & P(1)-C(14)-C(18) & 119.7 (4) \\ C(11)-C(14)-C($	O(6) - C(6)	1509(11)	O(6A) = O(6)	1 964 (17)
$\begin{array}{cccccc} 0(7)-C(7) & 1.346 (10) & 0(7A)-C(7) & 1.571 (14) \\ 0(8)-C(8) & 1.468 (8) & 0(9)-C(9) & 1.451 (8) \\ 0(10)-C(10) & 1.452 (8) & 0(11)-C(11) & 1.410 (10) \\ 0(12)-C(12) & 1.397 (10) & C(17)-C(13) & 1.399 (10) \\ C(16)-C(17) & 1.379 (10) & C(17)-C(18) & 1.399 (10) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.380 (8) \\ C(20)-C(21) & 1.387 (10) & C(23)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(2) & 86.5 (2) & P(1)-Ru-P(2) & 103.89 (5) \\ P(1)-Ru-P(3) & 158.27 (4) & P(1)-Ru-C(1) & 86.6 (2) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(2)-Ru-C(1) & 93.2 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(3)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 89.5 (2) \\ C(1)-Ru-C(2) & 172.5 (2) & Ru-Co-P(1) & 55.01 (3) \\ Ru-Co-P(4) & 153.50 (4) & Ru-Co-C(3) & 99.2 (2) \\ Ru-Co-C(4) & 92.1 (2) & P(1)-Co-P(4) & 99.32 (5) \\ P(4)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 17.1 (3) & Ru-P(1)-C(20) & 114.3 (2) \\ Co-P(1)-C(14) & 125.7 (2) & Co-P(1) & 51.01 (3) \\ Ru-P(1)-C(14) & 125.7 (2) & Co-P(1) & 120.3 (2) \\ C(14)-P(1)-C(20) & 99.7 (2) & Ru-P(2)-O(5) & 113.2 (2) \\ Ru-P(2)-O(6) & 123.4 (2) & Ru-P(2)-O(7) & 114.8 (2) \\ C(5)-P(2)-O(6) & 112.4 (4) & Ru-P(2)-O(7) & 124.8 (5) \\ O(5)-P(2)-O(7) & 96.0 (3) & O(5)-P(2)-O(7A) & 94.0 (6) \\ Ru-P(3)-O(10) & 121.9 (1) & O(8)-P(3)-O(10) & 97.3 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(12) & 114.2 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(13) & 97.4 (2) \\ Co-P(4)-O(11) & 121.7 (2) & O(11)-P(4)-O(12) & 114.8 (2) \\ P(2)-O(6)-C(5) & 123.4 (4) & P(2)-O(6)-C(6) & 121.0 (3) \\ P(2)-O(6)-C(5) & 123.4 (4) & P(2)-O(6)-C(6) & 121.0 (3) \\ P(2)-O(6)-C(5) & 123.4 (4) & P(2)-O(6)-C(6) & 122.6 (3) \\ P(2)-O(6)-C(5) & 123.4 (4) & P(1)-C(14)-C(15) & 123.5 (3) \\ P(1)-C(14)-C(15) & 117.4 (3) & P(1)-$	O(0) = C(0)	1.002 (11)	O(6A) - C(6)	1.204(17)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	O(7) - C(7)	1.346(10)	O(7A) - C(7)	1.571 (14)
$\begin{array}{c} O(10)-C(10) & 1.452 (8) & O(11)-C(11) & 1.410 (10) \\ O(12)-C(12) & 1.452 (8) & O(11)-C(11) & 1.410 (10) \\ O(12)-C(12) & 1.397 (10) & C(17)-C(13) & 1.399 (10) \\ C(18)-C(17) & 1.379 (10) & C(17)-C(18) & 1.399 (10) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.386 (8) \\ C(20)-C(21) & 1.393 (9) & C(22)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline C(24)-C(2) & 86.5 (2) & P(1)-Ru-P(2) & 103.899 (5) \\ P(1)-Ru-P(3) & 158.27 (4) & P(1)-Ru-P(2) & 103.899 (5) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(3)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 89.5 (2) \\ C(1)-Ru-C(2) & 172.5 (2) Ru-Co-P(1) & 55.01 (3) \\ Ru-Co-P(4) & 153.50 (4) & Ru-Co-C(3) & 99.2 (2) \\ Ru-Co-C(4) & 92.1 (2) & P(1)-Co-P(4) & 99.32 (5) \\ P(4)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 97.6 (2) & P(4)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 97.6 (2) & P(4)-Co-C(4) & 122.8 (2) \\ C(3)-Co-C(4) & 117.1 (3) Ru-P(1)-C(20) & 114.3 (2) \\ Co-P(1)-C(14) & 125.3 (2) Co-P(1)-C(20) & 114.3 (2) \\ Co-P(1)-C(14) & 125.3 (2) Co-P(1)-C(20) & 114.3 (2) \\ Co-P(2)-O(6) & 112.4 (4) Ru-P(2)-O(7) & 114.8 (2) \\ Ru-P(2)-O(6) & 112.4 (4) Ru-P(2)-O(7) & 128.7 (5) \\ O(5)-P(2)-O(6) & 112.4 (2) Ru-P(2)-O(6) & 113.2 (2) \\ Ru-P(2)-O(6) & 123.4 (2) Ru-P(2)-O(7) & 128.7 (5) \\ O(5)-P(2)-O(7) & 96.0 (3) & O(5)-P(2)-O(7) & 93.7 (3) \\ O(5)-P(2)-O(7) & 123.6 (3) & O(6)-P(2)-O(7) & 93.7 (3) \\ O(5)-P(2)-O(7) & 123.6 (3) & O(5)-P(2)-O(7) & 123.5 (4) \\ P(2)-O(6)-C(5) & 124.8 (4) & P(2)-O(6)-C(6) & 121.0 (3) \\ P(2)-O(6)-C(5) & 124.8 (4) & P(2)-O(6)-C(6) & 124.6 (3) \\ O(1)-P(4)-O(13) & 120.3 (4) \\ P(2)-O(6)-C(13) & 120.3 (4) \\ P(1)-C(14)-C(15) & 117.4 (3) & P(1)-C(14)-C(18)$	O(8) - C(8)	1 468 (8)	O(9) - C(9)	1 451 (8)
$\begin{array}{c} \text{O(10)-C(10)} & 1.422 (8) & \text{O(11)-C(11)} & 1.410 (10) \\ \text{O(12)-C(12)} & 1.448 (7) & \text{O(13)-C(13)} & 1.405 (9) \\ \text{C(14)-C(15)} & 1.397 (8) & \text{C(15)-C(16)} & 1.394 (9) \\ \text{C(16)-C(17)} & 1.379 (10) & \text{C(17)-C(18)} & 1.399 (10) \\ \text{C(20)-C(21)} & 1.393 (9) & \text{C(21)-C(22)} & 1.395 (9) \\ \text{C(22)-C(23)} & 1.387 (10) & \text{C(23)-C(24)} & 1.390 (11) \\ \text{C(24)-C(25)} & 1.405 (8) & \text{C(25)-C(20)} & 1.380 (8) \\ \hline \\ \text{Co-Ru-P(1)} & 48.99 (3) & \text{Co-Ru-P(2)} & 151.86 (4) \\ \text{Co-Ru-P(3)} & 109.44 (3) & \text{Co-Ru-P(1)} & 86.6 (2) \\ \text{Co-Ru-C(2)} & 86.5 (2) & \text{P(1)-Ru-P(2)} & 103.89 (5) \\ \text{P(1)-Ru-P(3)} & 158.27 (4) & \text{P(1)-Ru-P(2)} & 103.89 (5) \\ \text{P(2)-Ru-C(1)} & 93.2 (2) & \text{P(2)-Ru-P(3)} & 98.69 (5) \\ \text{P(2)-Ru-C(1)} & 93.2 (2) & \text{P(2)-Ru-C(2)} & 94.3 (2) \\ \text{P(3)-Ru-C(1)} & 90.1 (2) & \text{P(3)-Ru-C(2)} & 99.5 (2) \\ \text{C(1)-Ru-C(2)} & 172.5 (2) & \text{Ru-Co-P(1)} & 55.01 (3) \\ \text{Ru-Co-P(4)} & 153.50 (4) & \text{Ru-Co-C(3)} & 99.2 (2) \\ \text{Ru-Co-C(4)} & 92.1 (2) & \text{P(1)-Co-P(4)} & 99.32 (5) \\ \text{P(1)-Co-C(3)} & 173.8 (2) & \text{P(1)-Co-C(4)} & 122.8 (2) \\ \text{P(4)-Co-C(3)} & 97.6 (2) & \text{P(4)-Co-C(4)} & 92.4 (2) \\ \text{C(3)-Co-C(4)} & 117.1 (3) & \text{Ru-P(1)-C(20)} & 114.3 (2) \\ \text{Cu-P(1)-C(14)} & 125.3 (2) & \text{Co-P(1)-C(20)} & 120.3 (2) \\ \text{C(1)+P(1)-C(20)} & 99.7 (2) & \text{Ru-P(2)-O(7)} & 114.8 (2) \\ \text{Ru-P(2)-O(6)} & 123.4 (2) & \text{Ru-P(2)-O(7)} & 114.8 (2) \\ \text{Ru-P(2)-O(6)} & 123.4 (2) & \text{Ru-P(2)-O(7)} & 114.8 (2) \\ \text{Ru-P(2)-O(6)} & 110.7 (3) & \text{O(5)-P(2)-O(7)} & 93.7 (3) \\ \text{O(5)-P(2)-O(7)} & 96.0 (3) & \text{O(5)-P(2)-O(7)} & 93.7 (3) \\ \text{O(5)-P(2)-O(7)} & 150.3 & \text{O(6A)-P(2)-O(7A)} & 148.6 (2) \\ \text{Co-P(4)-O(13)} & 121.7 (2) & \text{O(11)-P(4)-O(12)} & 114.2 (2) \\ \text{Co-P(4)-O(13)} & 121.7 (2) & \text{O(11)-P(4)-O(13)} & 97.4 (2) \\ \text{Co-P(4)-O(13)} & 121.7 (2) & \text{O(11)-P(4)-O(13)} & 97.4 (2) \\ \text{Co-P(4)-O(13)} & 121.7 (2) & \text{O(11)-P(4)-O(13)} & 97.4 (2) \\ \text{Co-P(4)-O(13)} & 121.7 (2) & \text{O(11)-P(4)-O(13)} & 97.4 (2) \\ \text{Co-P(4)-O(13)} & 121.7 (2) & \text{O(11)-P(4)-O(13)} & 97.4 (2) \\ \text{Co-P(4)-O(13)} & 120.3 (4) & \text{P(1)-C(14)-C(15)} &$		1.450 (0)		1,401 (0)
$\begin{array}{ccccccc} 0(12)-C(12) & 1.448 (7) & 0(13)-C(13) & 1.405 (9) \\ C(14)-C(15) & 1.397 (10) & C(17)-C(18) & 1.399 (10) \\ C(18)-C(19) & 1.400 (9) & C(19)-C(14) & 1.380 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.395 (9) \\ C(22)-C(23) & 1.387 (10) & C(23)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline \\ Co-Ru-P(1) & 48.99 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-P(3) & 109.44 (3) & Co-Ru-C(1) & 86.6 (2) \\ Co-Ru-C(2) & 86.5 (2) & P(1)-Ru-P(2) & 103.89 (5) \\ P(1)-Ru-P(3) & 158.27 (4) & P(1)-Ru-P(3) & 98.69 (5) \\ P(2)-Ru-C(1) & 93.2 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(3)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 98.69 (5) \\ P(2)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 99.5 (2) \\ C(1)-Ru-C(2) & 172.5 (2) & Ru-Co-P(1) & 55.01 (3) \\ Ru-Co-P(4) & 153.50 (4) & Ru-Co-C(3) & 99.2 (2) \\ Ru-Co-C(4) & 92.1 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 97.6 (2) & P(4)-Co-C(4) & 98.4 (2) \\ C(3)-Co-C(4) & 117.1 (3) & Ru-P(1)-Co & 76.01 (3) \\ Ru-P(1)-C(14) & 127. (2) & Ru-P(2)-O(7) & 114.3 (2) \\ Co-P(1)-C(14) & 123.4 (2) & Ru-P(2)-O(7) & 114.3 (2) \\ Ca-P(2)-O(6) & 112.4 (4) & Ru-P(2)-O(7) & 128.7 (5) \\ O(5)-P(2)-O(6) & 110.7 (3) & O(5)-P(2)-O(7) & 93.7 (3) \\ O(5)-P(2)-O(6) & 110.1 (1) & Ru-P(3)-O(9) & 119.1 (1) \\ Ru-P(3)-O(10) & 121.9 (1) & O(8)-P(3)-O(10) & 97.3 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(12) & 114.2 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(12) & 114.2 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(13) & 97.4 (2) \\ Ru-P(3)-O(6) & 120.3 (3) & P(3)-O(10) & 97.3 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(13) & 97.4 (2) \\ Ru-P(3)-O(10) & 121.9 (1) & O(8)-P(3)-O(10) & 97.3 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(13) & 97.4 (2) \\ Ru-P(3)-O(10) & 121.9 (1) & O(8)-P(3)-O(13) & 97.4 (2) \\ Ru-P(3)-O(10) & 121.9 (1) & O(8)-P(3)-O(13) & 97.4 (2) \\ Ru-P(3)-O(10) & 121.9 (3) & C(4)-C(25)-C(20) & 123.5 (3) \\ P(2)-O(6)-C(21) & 119.8 (4) & P(2)-O(6)-C(6) & 120.4 (4) \\ P(1)-C(14)-C(15) & 119.1 (3) & C(14)-C(15)-C(16) & 120.4 (4) \\ P(1)-C(20)-C(21) & 119$	O(10) - O(10)	1.452 (8)	O(11)-O(11)	1.410(10)
$\begin{array}{ccccccc} C(14)-C(15) & 1.397 (8) & C(15)-C(16) & 1.394 (9) \\ C(16)-C(17) & 1.379 (10) & C(17)-C(18) & 1.399 (10) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.385 (9) \\ C(22)-C(23) & 1.387 (10) & C(23)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline \\ Co-Ru-P(1) & 48.99 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-C(2) & 86.5 (2) & P(1)-Ru-P(2) & 103.89 (5) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(1) & 86.6 (2) \\ Co-Ru-C(1) & 93.2 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(3)-Ru-C(1) & 93.2 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(3)-Ru-C(1) & 93.2 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(3)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 89.5 (2) \\ C(1)-Ru-C(2) & 172.5 (2) & Ru-Co-P(1) & 55.01 (3) \\ Ru-Co-P(4) & 153.50 (4) & Ru-Co-C(3) & 99.2 (2) \\ P(4)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 171.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 97.6 (2) & P(4)-Co-C(4) & 122.8 (2) \\ C(3)-Co-C(4) & 117.1 (3) & Ru-P(1)-C(20) & 114.3 (2) \\ C(3)-Co-C(4) & 112.4 (4) & Ru-P(2)-O(5) & 113.2 (2) \\ C(14)-P(1)-C(14) & 125.3 (2) & Co-P(1)-C(20) & 120.3 (2) \\ C(14)-P(1)-C(14) & 125.3 (2) & Co-P(1)-C(20) & 123.2 (2) \\ Ru-P(2)-O(6) & 123.4 (2) & Ru-P(2)-O(7) & 14.8 (2) \\ Ru-P(2)-O(6) & 123.4 (2) & Ru-P(2)-O(7) & 14.8 (2) \\ Ru-P(2)-O(6) & 101.1 (1) & Ru-P(3)-O(9) & 101.6 (2) \\ O(5)-P(2)-O(7A) & 113.9 (5) & O(6A)-P(2)-O(7A) & 94.0 (6) \\ Ru-P(3)-O(10) & 101.1 (1) & Ru-P(3)-O(9) & 101.6 (2) \\ O(5)-P(2)-O(7A) & 113.9 (5) & O(6A)-P(2)-O(7A) & 94.0 (6) \\ Ru-P(3)-O(10) & 121.7 (2) & O(11)-P(4)-O(12) & 104.1 (3) \\ O(5)-P(2)-O(7A) & 175.9 (3) & Co-C(4)-O(4) & 176.2 (3) \\ P(2)-O(7A)-C(7) & 122.1 (4) & P(3)-O(8)-C(8) & 122.6 (3) \\ P(2)-O(6A)-C(6) & 120.4 (4) & P(2)-O(7)-C(7) & 123.5 (4) \\ P(2)-O(6A)-C(6) & 120.4 (4) & P(4)-O(12)-C(10) & 121.0 (3) \\ P(4)-O(13) & -C(13) & 120.3 (4) \\ P(1)-C(14)-C(15) & 117.4 (3) & P(1)-C(14)-C(16) & 120.7 (3) \\ P(2)-O(6A)-C(6) & 120.4 (4) & P(1)-C(10)-C(14) & 128.5 (3) \\ C(14)-C(15)-C(17) & 129.4 (4) & C(22)-C(23)-C(24) & 120.9 (4) \\ C(23)-C(24)$	O(12)-C(12)	1.448(7)	O(13) - C(13)	1.405(9)
$\begin{array}{c} C(16)-C(17) & 1.379 & (0) & C(17)-C(18) & 1.394 & (0) \\ C(18)-C(19) & 1.400 & (9) & C(19)-C(14) & 1.380 & (8) \\ C(20)-C(21) & 1.393 & (9) & C(21)-C(22) & 1.395 & (9) \\ C(22)-C(23) & 1.387 & (10) & C(23)-C(24) & 1.390 & (11) \\ C(24)-C(25) & 1.405 & (8) & C(25)-C(20) & 1.380 & (8) \\ \hline \\ Co-Ru-P(1) & 48.99 & (3) & Co-Ru-P(2) & 151.86 & (4) \\ Co-Ru-P(3) & 109.44 & (3) & Co-Ru-P(2) & 151.86 & (4) \\ Co-Ru-C(2) & 86.5 & (2) & P(1)-Ru-P(2) & 103.89 & (5) \\ P(1)-Ru-C(2) & 91.3 & (2) & P(2)-Ru-P(3) & 98.69 & (5) \\ P(2)-Ru-C(1) & 93.2 & (2) & P(2)-Ru-C(2) & 94.3 & (2) \\ P(3)-Ru-C(1) & 90.1 & (2) & P(3)-Ru-C(2) & 94.3 & (2) \\ P(3)-Ru-C(1) & 90.1 & (2) & P(3)-Ru-C(2) & 94.3 & (2) \\ C(1)-Ru-C(2) & 172.5 & (2) & Ru-Co-P(1) & 55.01 & (3) \\ Ru-Co-P(4) & 153.50 & (4) & Ru-Co-C(3) & 99.2 & (2) \\ Ru-Co-C(3) & 97.6 & (2) & P(4)-Co-C(4) & 122.8 & (2) \\ P(4)-Co-C(3) & 97.6 & (2) & P(4)-Co-C(4) & 122.8 & (2) \\ P(4)-Co-C(3) & 97.6 & (2) & P(4)-Co-C(4) & 122.8 & (2) \\ P(4)-Co-C(3) & 97.6 & (2) & P(4)-Co-C(4) & 122.8 & (2) \\ P(4)-Co-C(3) & 97.6 & (2) & Ru-P(1)-C(20) & 114.3 & (2) \\ Co-P(1)-C(14) & 121.7 & (2) & Ru-P(2)-O(7) & 114.8 & (2) \\ Ca-P(1)-C(14) & 122.7 & (2) & Ru-P(2)-O(7) & 114.8 & (2) \\ Ru-P(2)-O(6) & 123.4 & (2) & Ru-P(2)-O(7) & 114.8 & (2) \\ Ru-P(2)-O(6) & 113.4 & (2) & Ru-P(2)-O(7) & 114.8 & (2) \\ Ru-P(2)-O(6) & 110.7 & (3) & O(5)-P(2)-O(6A) & 81.1 & (5) \\ O(5)-P(2)-O(7) & 96.0 & (3) & O(5)-P(2)-O(7A) & 94.0 & (6) \\ Ru-P(3)-O(10) & 121.9 & (1) & O(8)-P(3)-O(10) & 97.3 & (2) \\ Co-P(4)-O(11) & 119.2 & (2) & Co-P(4)-O(12) & 114.2 & (2) \\ Co-P(4)-O(13) & 121.7 & (2) & O(11)-P(4)-O(13) & 97.4 & (2) \\ O(5)-P(2)-O(6A) & 112.4 & (4) & P(2)-O(7)-C(7) & 123.5 & (4) \\ P(2)-O(7A)-C(7) & 123.1 & (4) & P(3)-O(8)-C(8) & 122.6 & (3) \\ P(2)-O(7A)-C(7) & 123.1 & (4) & P(4)-O(12) & 104.1 & (3) \\ O(1)-P(4)-O(13) & 120.3 & (4) & P(1)-C(14)-C(15) & 119.1 & (3) \\ C(1)-C(1)-C(11) & 124.3 & (4) & P(1)-C(14)-C(15) & 120.3 & (4) \\ P(1)-C(14)-C(15) & 119.1 & (3) & C(14)-C(15)-C(16) & 120.4 & (4) \\ P(1)-C(14)-C(15) & 119.1 & (3) & C(14)-C(15)-C($	$\dot{C}(14) = C(15)$	1 207 (8)	C(15)_C(16)	1 204 (0)
$\begin{array}{ccccc} C(16)-C(17) & 1.379 (10) & C(17)-C(18) & 1.399 (10) \\ C(18)-C(19) & 1.400 (9) & C(19)-C(14) & 1.380 (8) \\ C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.395 (9) \\ C(22)-C(23) & 1.387 (10) & C(23)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline \\ (b) Bond Angles \\ \hline \\ Co-Ru-P(1) & 48.99 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-C(2) & 86.5 (2) & P(1)-Ru-P(2) & 103.89 (5) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(1) & 86.3 (2) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-C(2) & 98.69 (5) \\ P(2)-Ru-C(1) & 93.2 (2) & P(2)-Ru-C(2) & 99.69 (5) \\ P(2)-Ru-C(1) & 90.1 (2) & P(3)-Ru-C(2) & 89.5 (2) \\ C(1)-Ru-C(2) & 172.5 (2) & Ru-Co-P(1) & 55.01 (3) \\ Ru-Co-P(4) & 153.50 (4) & Ru-Co-C(3) & 99.2 (2) \\ Ru-Co-C(4) & 92.1 (2) & P(1)-Co-C(4) & 192.8 (2) \\ P(4)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 98.4 (2) \\ C(3)-Co-C(4) & 117.1 (3) & Ru-P(1)-C(20) & 114.3 (2) \\ C(4)-P(1)-C(14) & 125.3 (2) & Co-P(1)-C(20) & 120.3 (2) \\ C(14)-P(1)-C(20) & 97.6 (2) & P(4)-Co-C(3) & 93.7 (3) \\ O(5)-P(2)-O(6A) & 112.4 (4) & Ru-P(2)-O(7A) & 128.7 (5) \\ O(5)-P(2)-O(6A) & 112.4 (4) & Ru-P(2)-O(7A) & 128.7 (5) \\ O(5)-P(2)-O(7A) & 113.9 (5) & O(6A)-P(2)-O(7A) & 94.0 (6) \\ Ru-P(3)-O(10) & 121.9 (1) & O(8)-P(3)-O(10) & 97.3 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(12) & 114.4 (2) \\ Co-P(4)-O(13) & 121.7 (2) & O(11)-P(4)-O(13) & 97.4 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(12) & 114.2 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(13) & 97.4 (2) \\ Co-P(4)-O(11) & 179.1 (2) & Ru-C(2)-O(2) & 177.4 (2) \\ Co-C(3)-O(3) & 175.9 (3) & Co-C(4)-O(4) & 176.2 (3) \\ P(2)-O(7A)-C(7) & 123.5 (4) & P(1)-C(14)-C(15) & 113.4 (4) & P(1)-O(13) & 97.4 (2) \\ C(1)-C(14)-C(15) & 119.1 (3) & C(14)-C(15)-C(16) & 120.4 (4) \\ P(2)-O(7A)-C(7) & 123.1 (4) & P(1)-C(10)-C(10) & 121.0 (3) \\ P(4)-O(13)-C(13) & 120.3 (4) & P(1)-C(14)-C(15) & 119.4 (4) & P(1)-C(14)-C(15) & 120.5 (4) \\ C(11)-C(14)-C(15) & 119.1 (3) & C(14)-C(15)-C(16) & 120.4 (4) \\ C(15)-C(16)-C(17) & 120.4 (4) & C(24)-C(25)-C(24) & 120.5 (4) \\ C(21)-$	C(14) = C(13)	1.007 (0)	C(10) - C(10)	1.004 (0)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	C(16) - C(17)	1.379(10)	C(17) - C(18)	1.399(10)
$\begin{array}{c} C(20)-C(21) & 1.393 (9) & C(21)-C(22) & 1.395 (9) \\ C(22)-C(23) & 1.387 (10) & C(23)-C(24) & 1.390 (11) \\ C(24)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline \\ (224)-C(25) & 1.405 (8) & C(25)-C(20) & 1.380 (8) \\ \hline \\ (20-Ru-P(1) & 48.99 (3) & Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-C(2) & 86.5 (2) & P(1)-Ru-P(2) & 103.89 (5) \\ P(1)-Ru-C(2) & 91.3 (2) & P(2)-Ru-P(3) & 98.69 (5) \\ P(2)-Ru-C(1) & 93.2 (2) & P(2)-Ru-C(2) & 94.3 (2) \\ P(2)-Ru-C(1) & 93.2 (2) & P(2)-Ru-C(2) & 89.5 (2) \\ C(1)-Ru-C(2) & 172.5 (2) & Ru-Co-P(1) & 55.01 (3) \\ Ru-Co-P(4) & 153.50 (4) & Ru-Co-C(3) & 99.2 (2) \\ Ru-Co-C(4) & 92.1 (2) & P(1)-Co-P(4) & 99.32 (5) \\ P(1)-Co-C(3) & 113.8 (2) & P(1)-Co-C(4) & 122.8 (2) \\ P(4)-Co-C(3) & 97.6 (2) & P(4)-Co-C(4) & 98.4 (2) \\ C(3)-Co-C(4) & 117.1 (3) & Ru-P(1)-C(20) & 114.3 (2) \\ Ru-P(2)-O(6) & 123.4 (2) & Co-P(1) & C(20) & 114.3 (2) \\ Ru-P(2)-O(6) & 123.4 (2) & Ru-P(2)-O(7) & 114.8 (2) \\ Ru-P(2)-O(6) & 123.4 (2) & Ru-P(2)-O(7) & 114.8 (2) \\ Ru-P(2)-O(6) & 113.9 (5) & O(6A)-P(2)-O(7A) & 122.7 (5) \\ O(5)-P(2)-O(7A) & 113.9 (5) & O(6A)-P(2)-O(7A) & 94.0 (6) \\ Ru-P(3)-O(8) & 110.1 (1) & Ru-P(3)-O(9) & 110.1 (2) \\ Ru-P(3)-O(10) & 121.9 (1) & O(8)-P(3)-O(10) & 97.3 (2) \\ Co-P(4)-O(11) & 119.2 (2) & Co-P(4)-O(12) & 144.2 (2) \\ Co-P(4)-O(13) & 121.7 (2) & O(11)-P(4)-O(12) & 104.1 (3) \\ P(2)-O(5)-C(5) & 124.8 (4) & P(2)-O(7)-C(7) & 123.5 (4) \\ P(2)-O(5A)-C(6) & 120.4 (4) & P(2)-O(7)-C(7) & 123.5 (4) \\ P(2)-O(5A)-C(7) & 123.0 (3) & P(3)-O(10) & 97.4 (2) \\ Co-C(3)-O(3) & 175.9 (3) & Co-C(4)-O(4) & 176.2 (3) \\ P(2)-O(5A)-C(7) & 123.0 (3) & P(3)-O(10)-C(10) & 121.0 (3) \\ P(4)-O(13) & -C(13) & 120.3 (4) \\ P(1)-C(14)-C(15) & 119.1 (3) & C(14)-C(15)-C(16) & 120.4 (4) \\ P(1)-C(14)-C(15) & 119.1 (3) & C(14)-C(15)-C(16) & 120.4 (4) \\ P(1)-C(14)-C(15) & 119.1 (3) & C(14)-C(15)-C(16) & 120.4 (4) \\ P(1)-C(14)-C(15) & 119.1 (3) & C(14)-C(15)-C(16) & 120.4 (4) \\ P(1)-C(14)-C(15) & 119.1 (3) & C(14)-C(25)-C(24) & 120.5 (3) \\ P(2)-O(2)-C(23) & 119.2 (4) & C(22)-C(23)-C(24) & 120.5 (4) \\ P(1)-C(20)-C(21) & 119.2 (4) & C(22)-C(2$	C(18) - C(19)	1 400 (9)	C(19) - C(14)	1 380 (8)
$\begin{array}{cccc} C(2)-C(21) & 1.393 \ (9) & C(21)-C(22) & 1.395 \ (9) \\ C(22)-C(23) & 1.387 \ (10) & C(23)-C(24) & 1.390 \ (11) \\ C(24)-C(25) & 1.405 \ (8) & C(25)-C(20) & 1.380 \ (8) \\ \end{array}$	O(10) O(10)	1,400 (0)	O(10) O(14)	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	C(20) - C(21)	1.393 (9)	U(21) - U(22)	1.395 (9)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	C(22)-C(23)	1.387(10)	C(23) - C(24)	1.390(11)
$\begin{array}{ccccc} (b) \ \mbox{Bond Angles} \\ (b) \ \mbox{Bond Angles} \\ Co-Ru-P(1) & 48.99 (3) \ Co-Ru-P(2) & 151.86 (4) \\ Co-Ru-C(2) & 86.5 (2) \ P(1)-Ru-P(2) & 103.89 (5) \\ P(1)-Ru-C(2) & 91.3 (2) \ P(2)-Ru-P(3) & 98.69 (5) \\ P(1)-Ru-C(2) & 91.3 (2) \ P(2)-Ru-P(3) & 98.69 (5) \\ P(2)-Ru-C(1) & 90.1 (2) \ P(3)-Ru-C(2) & 94.3 (2) \\ P(3)-Ru-C(1) & 90.1 (2) \ P(3)-Ru-C(2) & 99.5 (2) \\ C(1)-Ru-C(2) & 172.5 (2) \ Ru-Co-P(1) & 55.01 (3) \\ Ru-Co-P(4) & 153.50 (4) \ Ru-Co-C(3) & 99.2 (2) \\ Ru-Co-C(3) & 113.8 (2) \ P(1)-Co-P(4) & 99.32 (5) \\ P(4)-Co-C(3) & 113.8 (2) \ P(4)-Co-C(4) & 98.4 (2) \\ C(3)-Co-C(4) & 92.1 (2) \ P(4)-Co-C(4) & 98.4 (2) \\ C(3)-Co-C(4) & 171.1 (3) \ Ru-P(1)-Co-C(4) & 98.4 (2) \\ C(3)-Co-C(4) & 117.1 (3) \ Ru-P(1)-C(20) & 114.3 (2) \\ Ca-P(1)-C(14) & 125.3 (2) \ Co-P(1)-C(20) & 120.3 (2) \\ C(14)-P(1)-C(20) & 99.7 (2) \ Ru-P(2)-O(5) & 113.2 (2) \\ Ru-P(2)-O(6) & 112.4 (4) \ Ru-P(2)-O(7A) & 128.7 (5) \\ O(5)-P(2)-O(6) & 110.7 (3) \ O(5)-P(2)-O(7A) & 128.7 (5) \\ O(5)-P(2)-O(6) & 110.1 (1) \ Ru-P(3)-O(9) & 119.1 (1) \\ Ru-P(3)-O(10) & 121.9 (1) \ O(8)-P(3)-O(9) & 119.1 (1) \\ Ru-P(3)-O(10) & 121.9 (1) \ O(8)-P(3)-O(9) & 119.1 (1) \\ Ru-P(3)-O(10) & 121.9 (1) \ O(8)-P(3)-O(9) & 119.1 (1) \\ Ru-P(3)-O(10) & 121.9 (1) \ O(8)-P(3)-O(9) & 119.1 (1) \\ Ru-P(3)-O(10) & 121.9 (1) \ O(8)-P(3)-O(10) & 97.3 (2) \\ Co-P(4)-O(11) & 119.2 (2) \ Co-P(4)-O(12) & 114.2 (2) \\ Co-C(3)-O(3) & 175.9 (3) \ Co-C(4)-O(12) & 114.2 (2) \\ Co-C(3)-O(3) & 175.9 (3) \ Co-C(4)-O(14) & 176.2 (3) \\ P(2)-O(5)-C(5) & 124.8 (4) \ P(2)-O(7)-C(7) & 123.5 (4) \\ P(2)-O(7A)-C(7) & 122.1 (4) \ P(3)-O(8)-C(8) & 122.6 (3) \\ P(2)-O(5)-C(5) & 117.4 (3) \ P(1)-C(14)-C(19) & 123.5 (3) \\ C(14)-C(14)-C(15) & 117.4 (3) \ P(1)-C(14)-C(19) & 123.5 (3) \\ C(14)-C(13)-C(15) & 117.4 (3) \ P(1)-C(14)-C(18) & 119.7 (4) \\ C(15)-C(16)-C(17) & 120.4 (4) \ C(16)-C(17)-C(18) & 119.7 (4) \\ C(17)-C(18)-C(19) & 119.5 (4) \ C(24)-C(25)-C(20) & 120.0 (3) \\ C(20)-C(21) & 120.0 (3) \ C(20)-C(21) & 120.0 (3) \\ C(21)-C(22)-C(23) & 119.2 (4) \ C(22)-C(23)-C(24) & 120.9 (4) \\ C(21)-C(20)-C(23)$	C(24) $C(25)$	1 405 (9)	C(95) $C(90)$	1 200 (0)
(b) Bond AnglesCo-Ru-P(1)48.99 (3)Co-Ru-P(2)151.86 (4)Co-Ru-P(3)109.44 (3)Co-Ru-C(1)86.6 (2)Co-Ru-C(2)86.5 (2)P(1)-Ru-P(2)103.89 (5)P(1)-Ru-P(3)158.27 (4)P(1)-Ru-P(2)98.69 (5)P(2)-Ru-C(1)93.2 (2)P(2)-Ru-P(3)98.69 (5)P(2)-Ru-C(1)93.2 (2)P(2)-Ru-C(2)94.3 (2)P(3)-Ru-C(2)172.5 (2)Ru-Co-P(1)55.01 (3)Ru-Co-P(4)153.50 (4)Ru-Co-C(3)99.2 (2)Ru-Co-C(4)92.1 (2)P(1)-Co-P(4)99.32 (5)P(1)-Co-C(3)113.8 (2)P(1)-Co-C(4)122.8 (2)P(4)-Co-C(3)97.6 (2)P(4)-Co-C(4)98.4 (2)C(3)-Co-C(4)117.1 (3)Ru-P(1)-C(20)114.3 (2)Co-P(1)-C(14)121.7 (2)Ru-P(1)-C(20)120.3 (2)C(14)-P(1)-C(20)99.7 (2)Ru-P(2)-O(5)113.2 (2)Ru-P(2)-O(6)123.4 (2)Ru-P(2)-O(7)114.8 (2)Ru-P(2)-O(6)112.4 (4)Ru-P(2)-O(7)13.7 (3)O(6)-P(2)-O(7)96.0 (3)O(5)-P(2)-O(7A)94.0 (6)Ru-P(3)-O(8)110.1 (1)Ru-P(3)-O(9)110.6 (2)O(5)-P(2)-O(7A)113.9 (5)O(6A)-P(2)-O(7A)94.0 (6)Ru-P(3)-O(10)121.9 (1)O(8)-P(3)-O(10)97.3 (2)Co-P(4)-O(11)119.1 (2)Co-P(4)-O(12)114.2 (2)Co-P(4)-O(13)17.5 9 (3)Co-C(4)-O(14)176.2 (3)P(1)-P(4)-O(13)174.3 (2)O(1)-P(4)-O(13)97.4	C(24) = C(25)	1.400 (6)	C(23) = C(20)	1.000 (0)
		(1) 5		
$\begin{array}{llllllllllllllllllllllllllllllllllll$		(b) Bond	d Angles	
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$C_0 - R_0 - P(1)$	48.99(3)	Co-Bu-P(2)	151.86(4)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$D = \mathbf{D}(\mathbf{a})$	100 44 (0)	C_{2} D_{2} $O(1)$	
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$30-\mathrm{Ru}-\mathrm{P}(3)$	109.44(3)	Co-Ru-C(1)	80.0 (2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Co-Ru-C(2)	86.5(2)	P(1)-Ru-P(2)	103.89(5)
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$\mathbf{P}(1) = \mathbf{P}_{12} = \mathbf{P}(2)$	158 97 (4)	$P(1) = P_{11} = C(1)$	86 3 (2)
$\begin{split} & \text{P(1)}-\text{Ru}-\text{C(2)} & 91.3 (2) & \text{P(2)}-\text{Ru}-\text{P(3)} & 98.69 (5) \\ & \text{P(2)}-\text{Ru}-\text{C(1)} & 90.1 (2) & \text{P(3)}-\text{Ru}-\text{C(2)} & 94.3 (2) \\ & \text{P(3)}-\text{Ru}-\text{C(1)} & 90.1 (2) & \text{P(3)}-\text{Ru}-\text{C(2)} & 89.5 (2) \\ & \text{C(1)}-\text{Ru}-\text{C(2)} & 172.5 (2) & \text{Ru}-\text{Co}-\text{P(1)} & 55.01 (3) \\ & \text{Ru}-\text{Co}-\text{P(4)} & 153.50 (4) & \text{Ru}-\text{Co}-\text{P(4)} & 99.2 (2) \\ & \text{Ru}-\text{Co}-\text{C(4)} & 92.1 (2) & \text{P(1)}-\text{Co}-\text{C(4)} & 99.2 (2) \\ & \text{Ru}-\text{Co}-\text{C(3)} & 97.6 (2) & \text{P(4)}-\text{Co}-\text{C(4)} & 98.4 (2) \\ & \text{C(3)}-\text{Co}-\text{C(4)} & 171.1 (3) & \text{Ru}-\text{P(1)}-\text{Co} & 76.01 (3) \\ & \text{Ru}-\text{P(1)}-\text{C(14)} & 121.7 (2) & \text{Ru}-\text{P(1)}-\text{C(20)} & 114.3 (2) \\ & \text{Co}-\text{P(1)}-\text{C(14)} & 125.3 (2) & \text{Co}-\text{P(1)}-\text{C(20)} & 120.3 (2) \\ & \text{C(14)}-\text{P(1)}-\text{C(20)} & 99.7 (2) & \text{Ru}-\text{P(2)}-\text{O(5)} & 113.2 (2) \\ & \text{Ru}-\text{P(2)}-\text{O(6)} & 123.4 (2) & \text{Ru}-\text{P(2)}-\text{O(7)} & 114.8 (2) \\ & \text{Ru}-\text{P(2)}-\text{O(6)} & 110.7 (3) & \text{O(5)}-\text{P(2)}-\text{O(7)} & 128.7 (5) \\ & \text{O(5)}-\text{P(2)}-\text{O(6)} & 110.7 (3) & \text{O(5)}-\text{P(2)}-\text{O(7)} & 93.7 (3) \\ & \text{O(6)}-\text{P(2)}-\text{O(7)} & 16.0 (3) & \text{O(5)}-\text{P(2)}-\text{O(7A)} & 128.7 (5) \\ & \text{O(5)}-\text{P(2)}-\text{O(7A)} & 113.9 (5) & \text{O(6A)}-\text{P(2)}-\text{O(7A)} & 94.0 (6) \\ & \text{Ru}-\text{P(3)}-\text{O(10)} & 121.9 (1) & \text{O(8)}-\text{P(3)}-\text{O(9)} & 111.6 (2) \\ & \text{O(8)}-\text{P(3)}-\text{O(10)} & 121.9 (1) & \text{O(8)}-\text{P(3)}-\text{O(10)} & 97.3 (2) \\ & \text{Co}-\text{P(4)}-\text{O(11)} & 119.2 (2) & \text{Co}-\text{P(4)}-\text{O(12)} & 114.2 (2) \\ & \text{Co}-\text{P(4)}-\text{O(13)} & 121.7 (2) & \text{O(11)}-\text{P(4)}-\text{O(13)} & 97.4 (2) \\ & \text{Ru}-\text{C(1)}-\text{O(1)} & 175.9 (3) & \text{Co}-\text{C(4)}-\text{O(4)} & 176.2 (3) \\ & \text{P(2)}-\text{O(5)}-\text{C(5)} & 124.8 (4) & \text{P(2)}-\text{O(6)}-\text{C(6)} & 121.0 (3) \\ & \text{P(2)}-\text{O(6A}-\text{C(6)} & 120.4 (4) & \text{P(2)}-\text{O(10)} & 21.0 (3) \\ & \text{P(2)}-\text{O(6A}-\text{C(6)} & 120.4 (4) & \text{P(4)}-\text{O(12)}-\text{C(12)} & 123.5 (3) \\ & \text{P(4)}-\text{O(13)}-\text{C(13)} & 120.3 (3) & \text{P(1)}-\text{C(14)}-\text{C(19)} & 123.5 (3) \\ & \text{P(1)}-\text{C(14)}-\text{C(15)} & 119.1 (3) & \text{C(14)}-\text{C(15)} & 120.4 (4) \\ & \text{C(15)}-\text{C(16)} -\text{C(17)} & 120.4 (4) & \text{C(16)}-\text{C(17)} & 123.5 (3) \\ & \text{P(1)}-C$	F(1) = Ku = F(3)	100.27 (4)	$\Gamma(1)$ - Ru - $C(1)$	00.3 (2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	P(1)-Ru-C(2)	91.3(2)	P(2)-Ru-P(3)	98.69 (5)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$P(2) - R_{11} - C(1)$	93 2 (2)	$P(2) - R_{11} - C(2)$	94 3 (2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	(2) Ru $O(1)$	00.2(2)	P(2) = P(2)	09.5 (2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	P(3) - Ru - C(1)	90.1(2)	P(3)-Ru-C(2)	89.5 (2)
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	C(1)-Ru-C(2)	172.5(2)	Ru-Co-P(1)	55.01(3)
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$\mathbf{P}_{1} = \mathbf{C}_{0} = \mathbf{P}(\mathbf{A})$	152 50 (4)	$\mathbf{R}_{\mathbf{U}} = \mathbf{C}_{0} = \mathbf{C}_{0}(3)$	00 2 (2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	nu = C0 = F(4)	100.00 (4)	Ru-Co-C(3)	99.2 (4)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Ru-Co-C(4)	92.1(2)	P(1)-Co-P(4)	99.32 (5)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$P(1) = C_0 = C(3)$	113.8(2)	P(1)-Co-C(4)	122.8(2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$			P(4) = O(4)	00.4 (0)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	P(4) - Co - C(3)	97.6 (2)	P(4) - Co - C(4)	98.4 (2)
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$C(3) - C_0 - C(4)$	117.1(3)	Ru-P(1)-Co	76.01(3)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$P_{11} = P(1) = C(14)$	191 7 (9)	$P_{11} = P(1) = C(20)$	114 9 (9)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$(1)^{-1}(1)^{-1}(14)$	121.7(2)	$Ru^{-1}(1) - C(20)$	114.0 (2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$C_0 - P(1) - C(14)$	125.3(2)	Co-P(1)-C(20)	120.3(2)
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	C(14) - P(1) - C(20)	99.7(2)	Ru - P(2) - O(5)	113.2(2)
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	$D_{11} D(0) D(0)$	102 4 (0)	$\mathbf{P}_{11} = \mathbf{P}_{12} + \mathbf{O}_{12} + \mathbf{O}$	114 0 (0)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$\pi u - P(2) - O(6)$	123.4(2)	Ru = P(2) = O(7)	114.0(2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Ru-P(2)-O(6A)	112.4(4)	Ru-P(2)-O(7A)	128.7(5)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	D(5) - P(2) - O(6)	110.7(3)	O(5) - P(2) - O(7)	93 7 (3)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	D(0) = (2) = O(0)		O(5) P(2) O(1)	01.1 (5)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	J(6) - P(2) - O(7)	96.0 (3)	O(5) - P(2) - O(6A)	81.1 (5)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	O(5) - P(2) - O(7A)	113.9(5)	O(6A) - P(2) - O(7A)) 94.0 (6)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$P_{11} = P(3) = O(8)$	1101(1)	$R_{11} = P(3) = O(9)$	119 1 (1)
$\begin{array}{llllllllllllllllllllllllllllllllllll$		110.1(1)	R(1) = C(3)	101.0 (0)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Ru - P(3) - O(10)	121.9(1)	O(8) - P(3) - O(9)	101.6 (2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	O(8) - P(3) - O(10)	104.1(2)	O(9) - P(3) - O(10)	97.3(2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$P_{1} = P_{1} = (0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0$	110.2 (2)	$C \circ \mathbf{P}(A) = O(10)$	1149 (9)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	-F(4) = O(11)	119.2 (2)	C0=F(4)=O(12)	114.2(2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Co-P(4)-O(13)	121.7(2)	O(11) - P(4) - O(12)	104.1(3)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	D(11) = P(4) = O(13)	96.4(3)	O(12) - P(4) - O(13)	974 (2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$		100.4 (0)	O(12) = O(10)	107.4 (0)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	Ru = C(1) = O(1)	179.1(2)	Ru = C(2) = O(2)	177.4(2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	$C_0 - C(3) - O(3)$	175.9(3)	$C_{0}-C(4)-O(4)$	176.2(3)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	D(0) = O(5) = O(5)	194 9 (4)	$\mathbf{P}(2) = \mathbf{O}(\mathbf{e}) - \mathbf{O}(\mathbf{e})$	191 (2)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	P(2) = O(3) = C(3)	124.0 (4)	F(2) = O(0) = C(0)	121.0 (3)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	P(2) - O(6A) - C(6)	120.4(4)	P(2) = O(7) = C(7)	123.5(4)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	P(2) = O(7A) = C(7)	1221(4)	P(3) = O(8) = C(8)	122.6(3)
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	(-) O(0) O(0)	100.0 /0)	D(0) O(10) O(10)	1010(0)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	-(3)-0(9)-0(9)	123.0(3)	r(3) = O(10) = O(10)	121.0(3)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	P(4) - O(11) - C(11)	124.3(4)	P(4) - O(12) - C(12)	123.7(3)
$\begin{array}{cccccc} (14)-C(15) & 117.4 & (3) & P(1)-C(14)-C(19) & 123.5 & (3) \\ C(19)-C(14)-C(15) & 119.1 & (3) & C(14)-C(15)-C(16) & 120.4 & (4) \\ C(15)-C(16)-C(17) & 120.4 & (4) & C(16)-C(17)-C(18) & 119.7 & (4) \\ C(17)-C(18)-C(19) & 119.5 & (4) & C(18)-C(19)-C(14) & 120.8 & (4) \\ P(1)-C(20)-C(21) & 119.8 & (2) & P(1)-C(20)-C(25) & 120.2 & (2) \\ C(25)-C(20)-C(21) & 120.0 & (3) & C(20)-C(21)-C(22) & 120.5 & (4) \\ C(21)-C(22)-C(23) & 119.2 & (4) & C(22)-C(23)-C(24) & 120.9 & (4) \\ C(23)-C(24)-C(25) & 119.5 & (4) & C(24)-C(25)-C(20) & 120.0 & (3) \\ \end{array}$	P(4) = O(13) = C(13)	120.3(4)		
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	(1) O(10) O(10)		D(1) 0(14) 0(10)	100 = (0)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	C(1) - C(14) - C(15)	117.4 (3)	r(1) = C(14) = C(19)	123.5(3)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	C(19)-C(14)-C(15)	119.1(3)	C(14)-C(15)-C(16)	120.4(4)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	C(15) = C(16) = C(17)	120 4 (4)	C(16) - C(17) - C(18)	1197(4)
$\begin{array}{llllllllllllllllllllllllllllllllllll$	(10) 0(10) 0(11)	110 5 (1)	O(10) O(10) O(10)	
$\begin{array}{llllllllllllllllllllllllllllllllllll$	J(17)-U(18)U(19)	119.5(4)	U(18) - U(19) - U(14)	120.8 (4)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	P(1)-C(20)-C(21)	119.8(2)	P(1)-C(20)-C(25)	120.2(2)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	2(25)-C(20)-C(21)	120 0 (3)	C(20)-C(21)-C(22)	120.5(4)
C(21)-C(22)-C(23) 119.2 (4) $C(22)-C(23)-C(24)$ 120.9 (4) $C(23)-C(24)-C(25)$ 119.5 (4) $C(24)-C(25)-C(20)$ 120.0 (3)	D(20) = O(20) = O(21)	110.0 (0)	$O(20) O(21)^{-}O(24)$	
C(23)-C(24)-C(25) 119.5 (4) $C(24)-C(25)-C(20)$ 120.0 (3)	J(21)-C(22)-C(23)	119.2 (4)	C(22)+C(23)+C(24)	120.9 (4)
	C(23)-C(24)-C(25)	119.5(4)	C(24)-C(25)-C(20)) 120.0 (3)

centers of electron density. In subsequent cycles these two sites were refined with occupancy factors of ${}^{2}/{}_{3}$ and ${}^{1}/{}_{3}$. Convergence was achieved at R = 0.039 with the weighted residual $R_w = 0.048$ $(R_w = [\sum w ||F_o| - |F_c||^2 / \sum w |F_o|^2]^{1/2})$. A weighting scheme of the form $w^{-1} = 3.9 - 0.0788 |F_o| + 0.00153 |F_o|^2$ was employed in the

⁽¹⁵⁾ Carty, A. J.; Mott, G. N.; Taylor, N. J.; Yule, J. E. J. Am. Chem. Soc. 1978, 100, 3051.

⁽¹⁶⁾ International Tables for X-ray Crystallography; Kynoch Press: Birmingham, England, 1974; Vol. IV.

Table IV. ³¹P Chemical Shifts and Coupling Constants for $[(MeO)_3P](CO)_3Ru(\mu-PPh_2)Co(CO)_3 (2),^a [(MeO)_3P]_2(CO)_2Ru(\mu-PPh_2)Co(CO)_3 (3),^a and <math>[(MeO)_3P]_2(CO)_2Ru(\mu-PPh_2)Co(CO)_2[P(OMe)_3] (4)^b$

	δ			J, Hz						
	P ₁	P_2	P_3	P ₄	$\overline{{}^2J_{\mathrm{P}_1-\mathrm{P}_2}}$	$^{2}J_{P_{1}-P_{3}}$	$^{2}J_{P_{1}-P_{4}}$	${}^{2}J_{{ m P}_{2}-{ m P}_{3}}$	${}^{3}J_{{ m P}_{2}-{ m P}_{4}}$	³ J _{P3-P}
cis isomer 2a	177.8	147.4								
trans isomer 2b	181.8		148.5			173				
3a	173	151	150			188		22		
4	149	154.9	157.4	191.6	11.5	177.4	39.7	17.22	80.6	

^a In CDCl₃. ^b In toluene- d_8 .



last cycles of refinement. A final difference map exhibited maximum residuals of $0.78 e \text{ Å}^{-3}$. All refinements utilized the full matrix. Table II lists atomic positional parameters and Table III bond lengths and angles. Thermal parameters (Table S1) and structure factor amplitudes (Table S2) have been deposited as supplementary material.

Results and Discussion

Synthesis. The study of site selectivity in carbonyl substitution of the bimetallic system 1 by phosphine ligands led us^{13} to the following conclusions: (i) substitution takes place only at the Ru site; (ii) weak donor phosphines (arylphosphines) favor the formation of monosubstituted products of type 2, $L(OC)_3Ru(\mu-PPh_2)Co(CO)_3$, whereas with basic phosphines(PMe₂Ph, PMe₃) or secondary phosphines (Ph₂PH) the reactions proceeded to the disubstituted derivatives $L_2(OC)_2Ru(\mu-PPh_2)Co(CO)_3$ of type 3. In an attempt to examine how a weak donor phosphorus derivative with a small cone angle would modify this result, we reacted complex 1 with P(OMe)₃, a ligand which is also known to form strong metal-phosphorus bonds. An excess of $P(OMe)_3$ was reacted with 1 in THF, and the reaction was monitored by thin-layer chromatography. At room temperature no significant reaction was observed. When the reaction mixture was heated from 45 °C to reflux in THF, the formation of three types of complex was observed. At 45 °C for 12 h two red products were formed which were separated by column chromatography and identified as the monosubstituted complex 2(11%) and the disubstituted derivative 3 (Scheme I). On continued refluxing complexes 2 and 3 slowly disappeared, and after 12 h only a third red complex was present which was obtained by crystallization in ether in 85% yield and identified as the trisubstituted derivative 4 (Scheme I). The same complex 4 was also obtained in larger yield (76%)by reacting the disubstituted complex 3a with an excess of $P(OMe)_3$ in THF at reflux (12 h). These reactions thus suggest that (i) mono- and disubstitution at the Ru site is favored over substitution at cobalt and (ii) disubstitution



Figure 1. The molecular structure of $[(MeO)_3P]_2(CO)_2Ru(\mu-PPh_2)Co(CO)_2[P(OMe)_3]$ showing the atomic numbering.

at the Ru site appears to be necessary prior to substitution at cobalt.

Complexes 2 and 3a possess phosphite groups bonded only to the ruthenium atom as indicated by ³¹P NMR (Table IV). Complex 2 contains both cis (2a) and trans (2b) isomers. The coupling constant ${}^{2}J_{(\text{PPh}_{2})\text{P}-[(\text{MeO})_{3}\text{P})\text{P}}$ was observed only for the trans isomer 2b. Comparison of the ³¹P NMR spectra of 3a with those of other (L)₂(CO)₂Ru-(μ -PPh_{2})Co(CO)₃ derivatives¹³ establishes conclusively that 3a has a structure with two phosphites bonded to ruthenium in the equatorial plane respectively trans and cis to the PPh₂ group. Phosphorus-phosphorus coupling constants are, as expected, somewhat larger in the phosphite derivative. The ³¹P NMR spectrum of 4 will be discussed later.

Description and Discussion of the Structure of 4. A view of the molecule, looking down on the Ru-Co-P(1) plane, is illustrated in Figure 1. The two metal atoms are linked by a single diphenylphosphido bridge (Ru-P(1)-Co = 76.01 (3)°), and the Ru–Co distance of 2.7837 (7) Å is consistent with the presence of a strong metal-metal interaction. For comparison Ru-Co bond lengths in the related phosphido-bridged compounds $(PPh_3)(CO)_3Ru(\mu$ - $PPh_2)Co(CO)_3^{13}$ and $(PPh_3)(CO)_3Ru(\mu - PPh_2)Co(CO)_2$ -(PPh₃)¹⁷ are 2.7681 (4) and 2.750 (1) Å, respectively. In the present context the principal structural features of interest are the stereochemistries of the ruthenium and cobalt atoms and the locations of the three phosphite ligands. Although no structural data are available for the parent molecule $(CO)_4 Ru(\mu-PPh_2)Co(CO)_3$ ¹⁴ the structure of 4 (L = $P(OMe)_3$) can be clearly related to that of the monosubstituted triphenylphosphine complex 2 (L = PPh_3).¹³ In the latter molecule the stereochemistry of the ruthenium atom is that of a distorted octahedron with the phosphorus atom of the phosphine approximately trans

⁽¹⁷⁾ Foley, H. C.; Finch, W. C.; Pierpont, C. G.; Geoffroy, G. L. Organometallics 1982, 1, 1379.



Figure 2. The ³¹P NMR spectrum of $[(MeO)_3P]_2(CO)_2Ru(\mu-PPh_2)Co(CO)_2[P(OMe)_3]$ (4) at 297 K. The assignments refer to phosphorus nuclei labeled as in Figure 1.

to the Ru-Co vector and cis to the phosphido bridge. In 4, Ru, Co, and the three phosphorus atoms P(1), P(2), and P(3) define an approximate square plane with C(1)-P(1)and C(2)-O(2), respectively, below and above this plane. The phosphite atom P(2) occupies a similar position trans to the Ru-Co bond (P(2)-Ru-Co = 151.86 (4)°) as PPh₃ in 2 (L = PPh₃) with the second phosphite trans to the phosphido-bridge $(P(1)-Ru-P(3) = 158.27 (4)^\circ)$. The two phosphite ligands are thus cis to one another in the ruthenium coordination sphere $(P(2)-Ru-P(3) = 98.69 (5)^{\circ})$. The cobalt atom has a very distorted five-coordinate stereochemistry similar to that in 2 ($L = PPh_3$) but with one of the basal carbonyl groups in 2, that trans to the Co-Ru bond, substituted by the third phosphite ligand. Although the atoms P(2), Ru, Co, and P(4) are by no means colinear, the phosphites P(2) and P(4) are mutually trans to the Ru-Co bond, a fact which appears to be substantiated by the magnitude of the three-bond P-P coupling in the ³¹P spectra of 4. There is an interesting comparison of Ru–P bond lengths between 2 ($L = PPh_3$) and 4 ($L = P(OMe)_3$). In the triphenylphosphine derivative 2, the Ru-P(PPh₃) distance is 2.410 (3) Å, 0.155 Å longer than the corresponding distance (Ru-P(2) = 2.255)(2) Å in the phosphite complex 4. We have previously commented on the fact that in comparable stereochemical situations, M-P(phosphite) bond lengths are consistently shorter, at the level of 0.05-0.11 Å, than M-P(phosphine) bonds and provided possible explanations for this observation.¹⁸ In the present case, the comparison is not a precise one due to the differing degrees of substitution in 2 and 4; nevertheless, this difference (0.155 Å) and the shortness of Ru-P(2) in 4 when compared to the sum of the covalent radii for phosphorus (1.10 Å) and ruthenium $(\sim 1.40 \text{ Å})$ suggest that the phosphite is very strongly bound to the ruthenium atom. The second phosphite on ruthenium exhibits a somewhat longer Ru-P bond length (Ru-P(3) = 2.301 (1) Å) probably as a result of the high trans influence of the μ -PPh₂ group. For the phosphite coordinated to cobalt in 4 comparison with the X-ray data for (PPh₃)(CO)₃Ru(µ-PPh₂)Co(CO)₂(PPh₃)¹⁷ elicits similar conclusions regarding the length of the Co-P bonds, with the Co-P(OMe)₃ distance (2.090 (2) Å) significantly shorter



Figure 3. The ³¹P NMR spectrum of $[(MeO)_3P]_2(CO)_2Ru(\mu-PPh_2)Co(CO)_2[P(OMe_3)]$ (4) at 233 K.



Figure 4. A 2D COSY plot of the ³¹P NMR spectrum of $[(MeO)_3P]_2(CO)_2Ru(\mu-PPh_2)Co(CO)_2[P(OMe)_3]$ (4). Diagonal elements represent chemical shifts and off-diagonal elements ³¹P nuclei related by scalar coupling.

than either the Co-PPh₃ bond length (2.167 (3) Å) or the Co-PPh₂ (2.165 (1) Å) distance in 4.

³¹P NMR Studies of $[P(OMe)_3]_2(CO)_2Ru(\mu-PPh_2)-Co(CO)_2[P(OMe)_3]$ (4). In a previous study we reported the complex ³¹P NMR spectrum of 3 (L = PPh₂H), a molecule which exists in solution as a mixture of four geometrical isomers differing in stereochemistry at the quasioctahedral ruthenium atom.¹³ A satisfactory interpretation of the spectra of 3 (L = PPh₂H) was achieved by using high-field ³¹P NMR and 2D COSY techniques. We have now applied these methods to 4 (L = P(OMe)₃), a molecule which might be predicted from the ORTEP plot of Figure 1 to present a second-order ABXM spin system. At 32.38 MHz the ³¹P{¹H} spectrum is complex. Greater detail is evident at 121.5 MHz (Figure 2), and a full analysis is possible from spectra at lower temperatures (Figure 3) in conjunction with a COSY experiment which

⁽¹⁸⁾ Robert, P.; LeBozec, H.; Dixneuf, P. H.; Hartstock, F.; Taylor, N. J.; Carty, A. J. Organometallics, 1982, 1, 1148.

reveals all of the scalar P-P couplings (Figure 4). In the following discussion phosphorus nuclei are numbered according to Figure 1.

At ambient temperature the 121.5-MHz spectrum (Figure 2) shows a broad unresolved downfield resonance at 190.52 ppm, a pair of doublets at 158.13 and 156.70 ppm, a pair of doublets at 155.23 and 154.58 ppm, and a pair of broad doublets at 149.74 and 148.31 ppm. Although at first sight it might be assumed that the low-field signal arises from the μ -PPh₂ group, variable-temperature studies show that this resonance broadens and collapses faster than the high-field doublet of doublets as the temperature is raised. This line broadening can be attributed to the quadrupolar effects of the ⁵⁹Co (I = 7/2) nucleus. Moreover at low temperatures (Figure 3) additional fine structure is resolved in the high-field doublets, whereas the low-field signal remains as a doublet of doublets. We assign the low-field resonance to the phosphite bound to cobalt (P4) and the high-field resonances to P(1) of the phosphido group. Although the high-field resonance signal appears as a doublet of doublets (Figure 3), the COSY spectrum (Figure 4) indicates that the corresponding ³¹P nucleus P(1) is coupled to three other phosphorus nuclei, P(2), P(3), and P(4). The COSY spectrum also shows that P(2)is coupled to three other phosphorus nuclei, P(2), P(3), and P(4), P(2) is coupled with P(1), P(3), and P(4), P(3) is coupled only to P(1) and P(2), and P(4) is coupled to P(1)and P(2). A complete analysis of shifts and coupling constants is given in Table IV.

There are several notable features of this assignment: (i) ${}^{2}J_{P(1)-P(3)}$ is large (177.4 Hz) as expected for two trans related ligands. Trans ${}^{2}J_{P-P(\mu-PPh_{2})}$ values in 3 (L = PPh₃H)¹³ and (L)(CO)₂Ru(μ -PPh₂)(μ -C=C-*i*-Pr)Ru(CO)₃ (L = Ph₂PC=C-*i*-Pr)¹⁹ are 183 and 215 Hz, respectively; (ii) ${}^{3}J_{P(2)-P(4)}$ (80.6 Hz) is significantly larger than any of the cis couplings in this molecule, consistent with a significant interaction between P(2) and P(4) through the Ru-Co bond *trans* to both ligands; (iii) of the remaining ${}^{2}J_{P-P}$ values all of which are cis couplings, the largest is ${}^{2}J_{P(1)-P(4)}$ (39.7 Hz) between the cobalt coordinated phosphite and the bridging phosphorus nucleus and the smallest ${}^{2}J_{P(1)-P(2)}$ of 11.5 Hz. For the compounds of type 3 (L = phosphine) no cis coupling between the μ -PPh₂ group and equatorial phosphines was observable. These results are in agreement with the fact that P-P couplings to phosphite ligands are invariably larger than those to phosphines probably as a result of increased "s" character in the M-P (phosphite) bonds.

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Registry No. 1, 82544-75-0; **2a**, 103533-71-7; **2b**, 103617-40-9; **3a**, 103533-72-8; **4**, 103533-73-9; Co, 7440-48-4; Ru, 7440-18-8.

Supplementary Material Available: A table of thermal parameters (1 page); a listing of structure factor amplitudes (22 pages). Ordering information is given on any current masthead page.

(19) (a) MacLaughlin, S. A.; Randall, L.; Carty, A. J., unpublished results. (b) Carty, A. J. Adv. Chem. Ser. 1981, No. 196, 163.

Oxidative-Addition and Proton-Transfer Reactions of Fluorocarbon Acids. Structures of $trans-(Ph_3P)_2Pt(H_2O)(PhC=CHPh)^+HC(SO_2CF_3)_2^-$ and $trans-(Ph_3P)_2PtH[C-HC(SO_2CF_3)_2]^{\dagger}$

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Oxidative addition of $H_2C(SO_2CF_3)_2$ to $(Ph_3P)_2Pt(PhC \cong CPh)$ yields the *trans*-diphenylvinyl compound *trans*- $(Ph_3P)_2Pt(trans-PhC = CHPh)[C-HC(SO_2CF_3)_2]$ in which restricted rotation about the Pt-HC(SO_2CF_3)_2 bond has been characterized by ³¹P DNMR spectroscopy. Recrystallization in air from isopropyl alcohol affords *trans*- $(Ph_3P)_2Pt(trans-PhC = CHPh)(H_2O)^+HC(SO_2CF_3)_2^-$: $P2_1/n$, monoclinic, a = 12.478 (5) Å, b = 18.935 (5) Å, c = 21.891 (4) Å, $\beta = 100.43$ (2)°, R = 0.053. Oxidative addition of $H_2C(SO_2CF_3)_2$ to $(Ph_3P)_2Pt(C_2H_4)$ forms $(Ph_3P)_2PtH[C-HC(SO_2CF_3)_2]$: $P2_1/c$, monoclinic, a = 17.555 (2) Å, b = 13.650 (1) Å, c = 17.880 (3) Å, $\beta = 112.70$ (1)°, R = 0.038. Analysis of the structural data reveals $H_2C(SO_2CF_3)_2$ to be a large, highly hindered carbon acid, and it is probable that steric effects contribute to the tendency of $HC(SO_2CF_3)_2^-$ to exist as an anion rather than coordinate to electron-deficient metal centers following proton transfer.

Introduction

We have previously outlined the organometallic chemistry of fluorocarbon acids of the type $RHC(SO_2CF_3)_2$ (R = H, Ph).¹ These acids possess an unusual collection of properties in that they are strong, nonhygroscopic, no-noxidizing protic acids whose conjugate bases have been shown² to coordinate to transition metals, via the central,

 $^{^{\}dagger} The C-HC(SO_2CF_3)_2$ formulation indicates that the CH(SO_2CF_3)_2 group is bonded to Pt via the methine carbon atom.

⁽¹⁾ Siedle, A. R.; Newmark, R. A.; Pignolet, L. H.; Howells, R. D. J. Am. Chem. Soc. 1984, 106, 1510.