One to chelate them all: towards a versatile, bifunctional chelator for ^{64}Cu, ^{99m}Tc, $^{186/188}$Re, ^{55}Co

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Supporting Information

1. Labeling traces

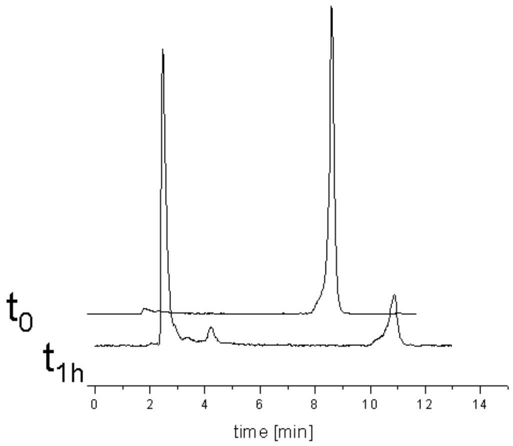

Figure S1. Labeling traces of ^{64}Cu(dipin) [t_0] and trace after 1h serum challenge experiment [t_{1h}]. The stacked graphs illustrate the transchelation event from chelate to serum within only one hour of stability evaluation.

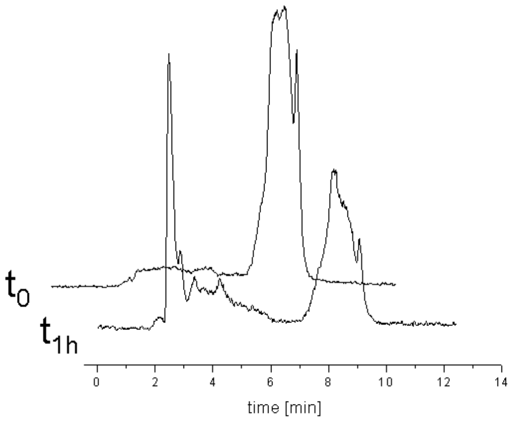

Figure S2. Labeling traces of ^{64}Cu(dipiam-Biotin) [t_0] and trace after 1h serum challenge experiment [t_{1h}]. The stacked graphs illustrate the transchelation event from chelate to serum within only one hour of stability evaluation. The broad peak also indicates formation of diastereotopic structures upon coordination of the metal.

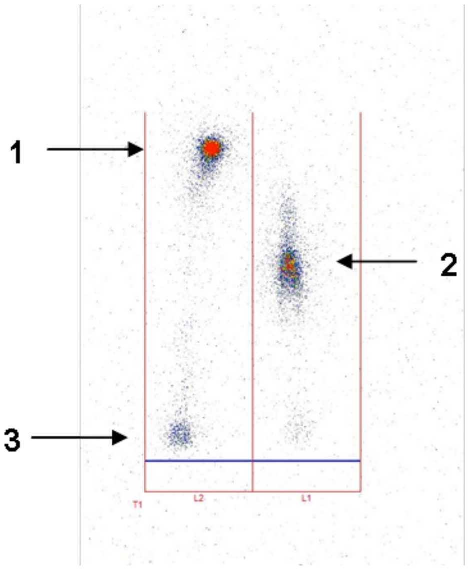

Figure S3. TLC labeling traces of $[^{99m}Tc(CO)_3(\mathbf{3})]^+$ (left, spot 1) and $[^{99m}Tc(CO)_3(\mathbf{7})]^+$ (right, spot 2). Bottom spots indicate unreacted $[^{99m}Tc(CO)_3(H_2O)_3]^+$ (bottom, spot 3).

2. Crystallographic data

2.1. [Cu(**4**)(H_2O)]

A green plate crystal of $C_{21}H_{18}N_4O_7Cu$ having approximate dimensions of 0.02 x 0.15 x 0.25 mm was mounted on a glass fiber. All measurements were made on a Bruker DUO APEX II diffractometer with graphite monochromated Mo-Kα radiation.

The data were collected at a temperature of -183.0 ± 0.1°C to a maximum 2θ value of 45.2°. Data were collected in a series of ϕ and ω scans in 0.50° oscillations with 60.0-second exposures. The crystal-to-detector distance was 40.00 mm.

2.1.1. Data Reduction

Of the 6190 reflections that were collected, 2560 were unique (R_{int} = 0.072); equivalent reflections were merged. Data were collected and integrated using the Bruker SAINT[1] software package. The linear absorption coefficient, μ, for Mo-Kα radiation is 11.55 cm^{-1}. Data were corrected for absorption effects using the multi-scan technique (SADABS[2]), with minimum and maximum transmission coefficients of 0.730 and 0.977, respectively. The data were corrected for Lorentz and polarization effects.

2.1. 2. Structure Solution and Refinement

The structure was solved by direct methods[3]. All non-hydrogen atoms were refined anisotropically. All hydrogen atoms were placed in calculated positions. SIMU/ISOR restraints were used to maintain reasonable displacement parameters. The final cycle of full-matrix least-squares refinement[4] on F^2 was based on 2560 reflections and 306 variable parameters and converged (largest parameter shift was 0.00 times its esd) with unweighted and weighted agreement factors of:

$$R1 = \Sigma ||Fo| - |Fc|| / \Sigma |Fo| = 0.130$$

$$wR2 = [\Sigma (w (Fo^2 - Fc^2)^2)/ \Sigma w(Fo^2)^2]^{1/2} = 0.254$$

The standard deviation of an observation of unit weight[5] was 1.16. The weighting scheme was based on counting statistics. The maximum and minimum peaks on the final difference Fourier map corresponded to 1.46 and –0.60 $e^-/Å^3$, respectively. Neutral atom scattering factors were taken from Cromer and Waber[6]. Anomalous dispersion effects were included in Fcalc[7]; the values for Δf' and Δf" were those of Creagh and McAuley[8]. The values for the mass attenuation coefficients are those of Creagh and Hubbell[9]. All refinements were performed using the SHELXL-97[10] via the WinGX[11] interface.

2.1. 3. Structural data - [Cu(**4**)(H_2O)]

Empirical Formula	$C_{21}H_{18}N_4O_7Cu$
Formula Weight	501.93
Crystal Colour, Habit	green, plate
Crystal Dimensions	0.02 X 0.15 X 0.25 mm
Crystal System	triclinic
Lattice Type	primitive
Lattice Parameters	a = 7.143(2) Å b = 8.335(2) Å c = 18.901(5) Å $\alpha = 77.781(4)^{o}$ $\beta = 79.755(5)\ ^{o}$ $\gamma = 65.266(4)\ ^{o}$ V = 993.9(5) Å^{3}
Space Group	*P* -1 (#2)
Z value	2
D_{calc}	1.677 g/cm^{3}
F_{000}	514.00
μ(MoKα)	11.55 cm^{-1}

Relevant bond angles [°]:

C1 O1 Cu1 116.2(6)
C8 O3 Cu1 117.7(8)
Cu1 O7 H7D 146(9)
Cu1 O7 H7E 110(9)
O3 Cu1 O1 90.7(3)
O3 Cu1 N1 168.6(4)
O1 Cu1 N1 81.3(3)
O3 Cu1 N2 82.9(4)
O1 Cu1 N2 138.8(3)
N1 Cu1 N2 108.5(4)
O3 Cu1 O7 86.5(3)
O1 Cu1 O7 117.9(3)
N1 Cu1 O7 90.1(4)
N2 Cu1 O7 102.3(3)

Relevant bond lengths [Å]:

N1 Cu1 2.005(10)
N2 Cu1 2.061(9)
O1 Cu1 1.988(7)
O3 Cu1 1.927(8)
O7 Cu1 2.155(8)

2.2 $[Re(CO)_3(\mathbf{3})]_2[Re(CO)_3Br_3]$

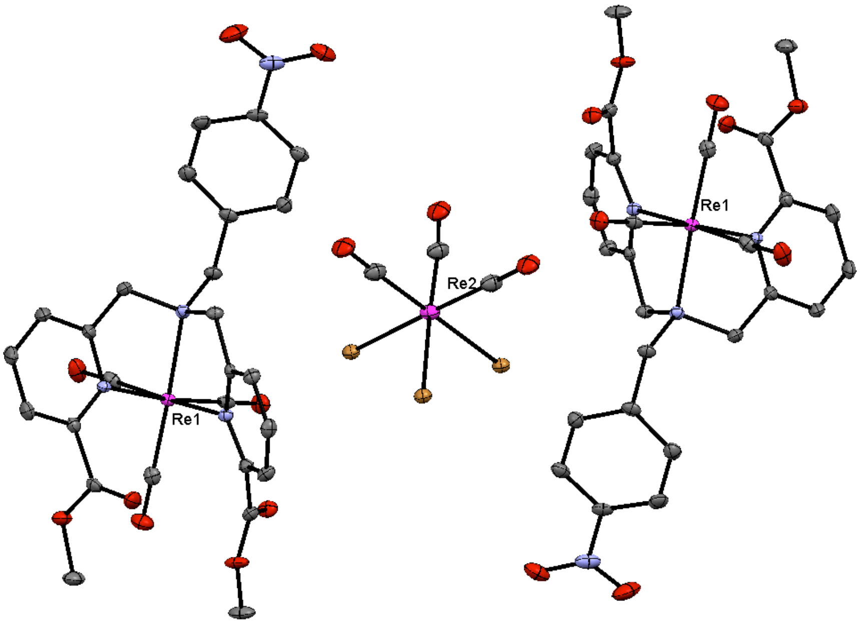

Figure S4. ORTEP showing one Re-anion with two Re-cation complexes.

2. 2. 1. Data Collection

A colourless blade crystal of $C_{26}H_{22}N_4O_9Re.½Re(CO)_3Br_3$ having approximate dimensions of 0.02 x 0.10 x 0.40 mm was mounted on a glass fiber. All measurements were made on a Bruker APEX DUO diffractometer with graphite monochromated Mo-Kα radiation.

The data were collected at a temperature of $-183.0 \pm 0.1^{o}C$ to a maximum 2θ value of 58.4^{o}. Data were collected in a series of ϕ and ω scans in 0.5^{o} oscillations using 20.0-second exposures. The crystal-to-detector distance was 40.00 mm.

2. 2. 2. Data Reduction

Of the 50217 reflections that were collected, 8033 were unique ($R_{int} = 0.048$); equivalent reflections were merged. Data were collected and integrated using the Bruker SAINT[1] software package. The linear absorption coefficient, μ, for Mo-Kα radiation is 81.83 cm^{-1}. Data were corrected for absorption effects using the multi-scan technique (SADABS[2]), with minimum and maximum transmission coefficients of 0.611 and 0.849, respectively. The data were corrected for Lorentz and polarization effects.

2. 2. 3. Structure Solution and Refinement

The structure was solved by direct methods[3]. The material crystallizes with $[Re(CO)_3Br_3]^{2-}$ as the counter anion. This anion resides on an inversion centre, thus there are Re cations per Re anion in the unit cell. The Re anion is also disordered, with both Br and CO with half-occupancy at each position octahedrally around the Re centre. All non-hydrogen atoms were refined anisotropically. All hydrogen atoms were placed in calculated positions. The final cycle of full-matrix least-squares refinement[4] on F^2 was based on 8033 reflections and 416 variable parameters and converged (largest parameter shift was 0.00 times its esd) with unweighted and weighted agreement factors of:

$$R1 = \Sigma ||Fo| - |Fc|| / \Sigma |Fo| = 0.035$$

$$wR2 = [\Sigma (w (Fo^2 - Fc^2)^2)/ \Sigma w(Fo^2)^2]^{1/2} = 0.047$$

The standard deviation of an observation of unit weight[5] was 1.02. The weighting scheme was based on counting statistics. The maximum and minimum peaks on the final difference Fourier map corresponded to 1.32 and –1.06 $e^-/Å^3$, respectively.

Neutral atom scattering factors were taken from Cromer and Waber[6]. Anomalous dispersion effects were included in Fcalc[7]; the values for $\Delta f'$ and $\Delta f''$ were those of Creagh and McAuley[8]. The values for the mass attenuation coefficients are those of Creagh and Hubbell[9]. All refinements were performed using the SHELXL-97[10] via the WinGX[11] interface.

2. 2. 4. Structural data - $[\mathrm{Re(CO)_3}(\mathbf{3})]_2[\mathrm{Re(CO)_3Br_3}]$

Empirical Formula	$C_{27.5}H_{22}N_4O_{10.5}Re_{1.5}Br_{1.5}$
Formula Weight	975.66
Crystal Colour, Habit	colourless, blade
Crystal Dimensions	0.02 X 0.10 X 0.40 mm
Crystal System	monoclinic
Lattice Type	Primitive
Lattice Parameters	a = 12.3723(10) Å b = 17.524(2) Å c = 14.840(1) Å $\alpha = 90^{\circ}$ $\beta = 112.128(2)^{\circ}$ $\gamma = 90^{\circ}$ V = 2980.5(4) Å^3
Space Group	$P\,2_1/c$ (#14)
Z value	4
D_{calc}	2.174 g/cm^3
F_{000}	1856.00
μ(Mo-Kα)	81.73 cm^{-1}

Relevant bond angles [°]:

C25 Re1 C26 85.30(13)
C25 Re1 C24 86.18(13)
C26 Re1 C24 90.62(12)
C25 Re1 N1 98.85(11)
C26 Re1 N1 172.66(11)
C24 Re1 N1 95.68(11)
C25 Re1 N2 100.24(11)
C26 Re1 N2 89.26(11)
C24 Re1 N2 173.54(11)
N1 Re1 N2 84.06(9)
C25 Re1 N3 174.79(11)
C26 Re1 N3 96.51(11)
C24 Re1 N3 98.66(11)
N1 Re1 N3 78.85(9)
N2 Re1 N3 74.94(9)

Relevant bond lengths [Å]:

N1 Re1 2.201(2)
N2 Re1 2.209(2)
N3 Re1 2.240(2)
C24 Re1 1.929(3)
C25 O8 1.161(4)
C25 Re1 1.902(3)
C26 O9 1.153(4)
C26 Re1 1.915(3)

3. NMR spectral data

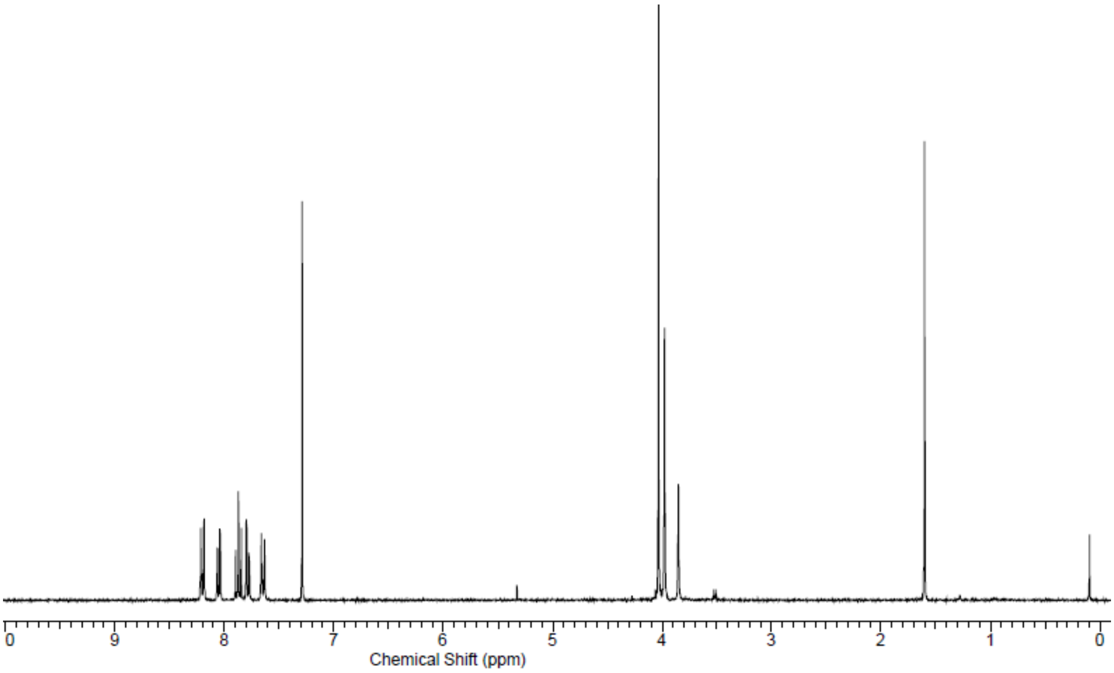

Figure S5. ^{1}H (300 MHz, $CDCl_3$, 298 K) spectrum of compound **3**.

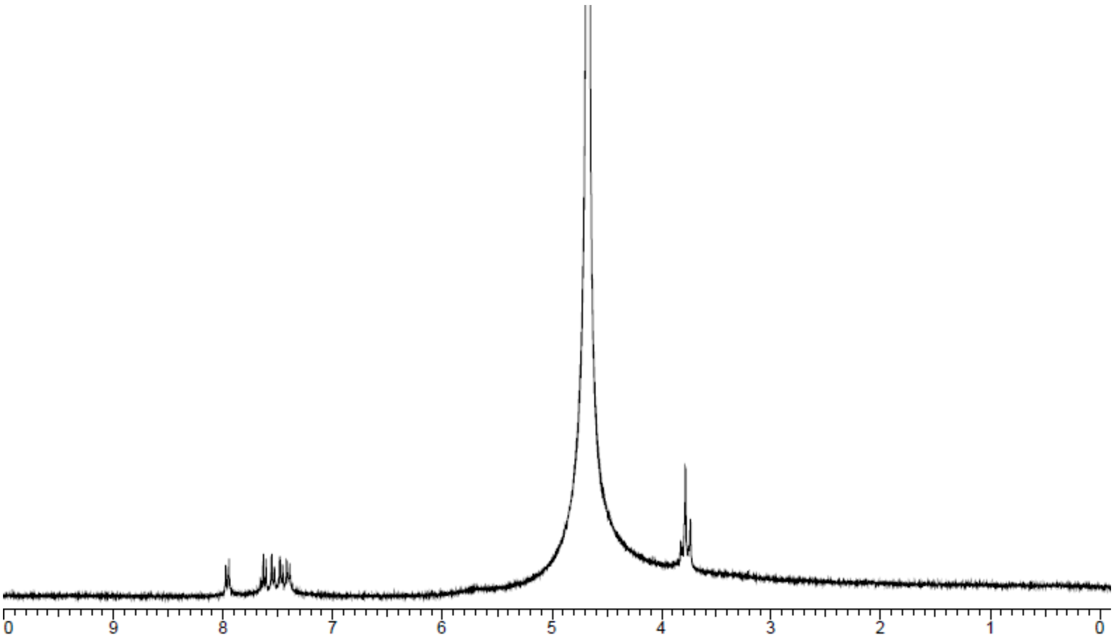

Figure S6. ^{1}H (300 MHz, D_2O, 298 K) spectrum of compound **4**.

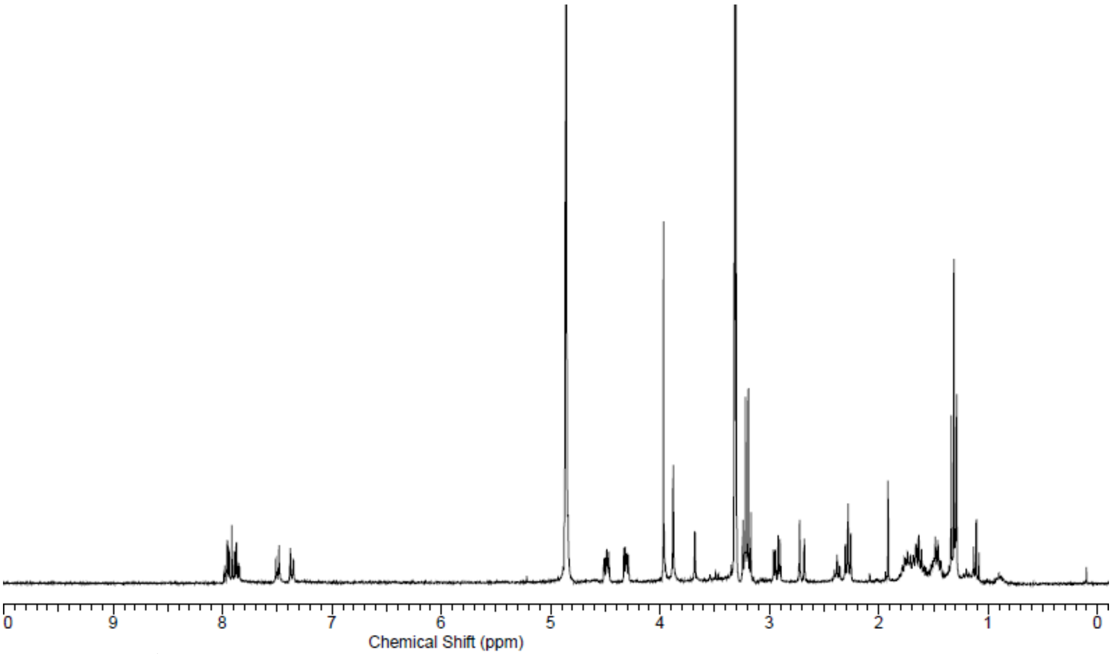

Figure S7. ^{1}H (300 MHz, CD_3OD, 298 K) spectrum of compound **7**.

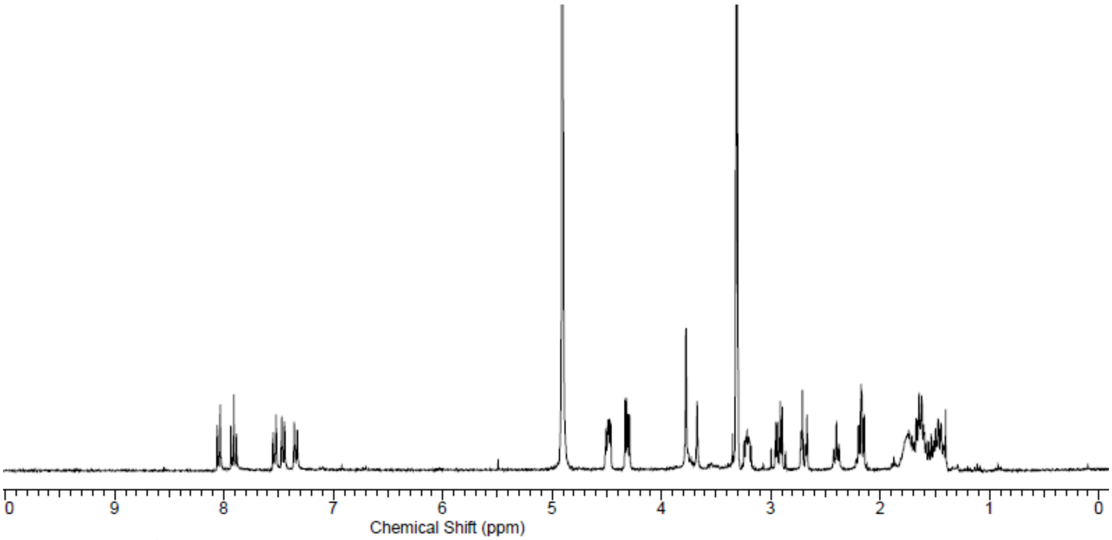

Figure S8. ^{1}H (300 MHz, CD_3OD, 298 K) spectrum of compound **8**.

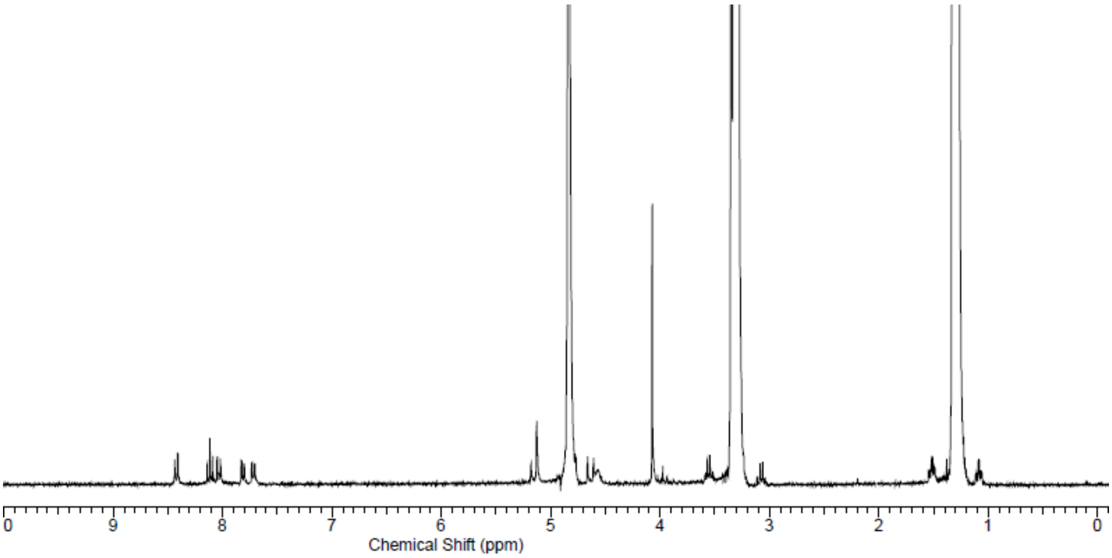

Figure S9. ^{1}H (300 MHz, CD_3OD, 298 K) spectrum of compound [Re(CO)$_3$**(3)**]Br

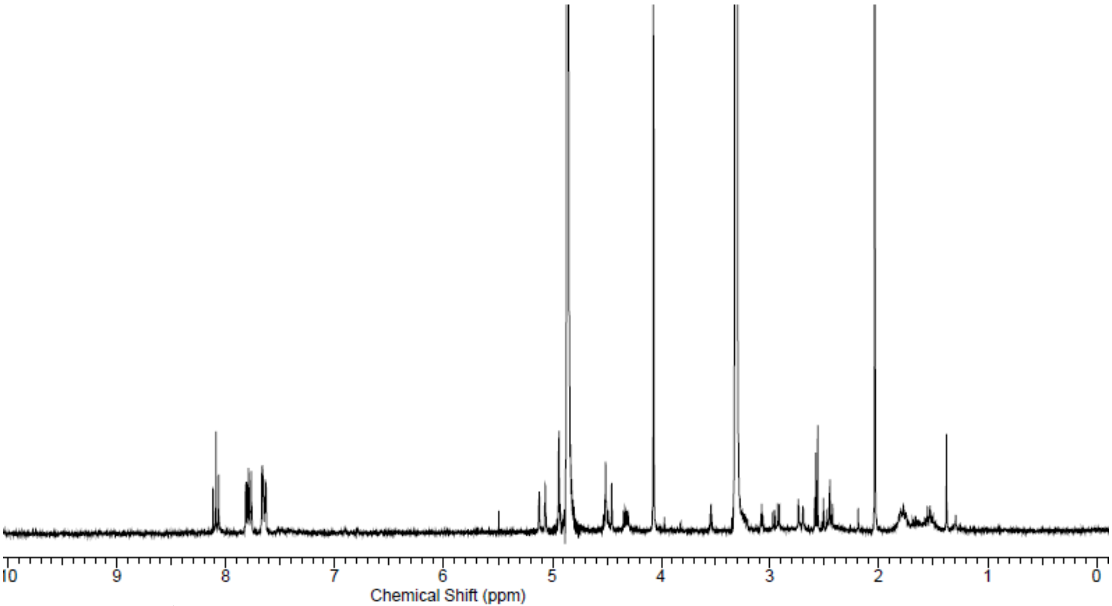

Figure S10. ^{1}H (300 MHz, CD_3OD, 298 K) spectrum of compound [Re(CO)$_3$**(7)**]Br

References

(1) SAINT. Version 7.60A. Bruker AXS Inc., Madison, Wisconsin, USA. (1997-2009).

(2) SADABS. Bruker Nonius area detector scaling and absorption correction - V2008/1, Bruker AXS Inc., Madison, Wisconsin, USA (2008).

(3) SIR97 - Altomare A., Burla M.C., Camalli M., Cascarano G.L., Giacovazzo C. , Guagliardi A., Moliterni A.G.G., Polidori G.,Spagna R. J. Appl. Cryst. 32, 115-119 (1999).

(4) Least Squares function minimized:

$$\Sigma w(F_o^2-F_c^2)^2$$

(5) Standard deviation of an observation of unit weight:

$$[\Sigma w(F_o^2-F_c^2)^2/(N_o-N_v)]^{1/2}$$

where: N_o = number of observations
N_v = number of variables

(6) Cromer, D. T. & Waber, J. T.; "International Tables for X-ray Crystallography", Vol. IV, The Kynoch Press, Birmingham, England, Table 2.2 A (1974).

(7) Ibers, J. A. & Hamilton, W. C.; Acta Crystallogr., 17, 781 (1964).

(8) Creagh, D. C. & McAuley, W.J .; "International Tables for Crystallography", Vol C, (A.J.C. Wilson, ed.), Kluwer Academic Publishers, Boston, Table 4.2.6.8, pages 219-222 (1992).

(9) Creagh, D. C. & Hubbell, J.H..; "International Tables for Crystallography", Vol C, (A.J.C. Wilson, ed.), Kluwer Academic Publishers, Boston, Table 4.2.4.3, pages 200-206 (1992).

(10) SHELXTL Version 5.1. Bruker AXS Inc., Madison, Wisconsin, USA. (1997).

(11) WinGX – V1.70 – Farrugia, L.J.; J. Appl. Cryst., 32, 837 (1999).