Electronic Supplementary Information (ESI)

Unprecedented twofold intramolecular hydroamination in diam(m)inedicarboxylatodichloridoplatinum(IV) complexes – ethane-1,2-diamine *versus* ammine ligands

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EXPERIMENTAL

All reagents and solvents were obtained from commercial suppliers, and were used as received. For column chromatography, silica gel 60 (Fluka) was used. The starting compounds (OC-6-33)-dichlorido(ethane-1,2-diamine)dihydroxoplatinum(IV) 1 and (OC-6-33)-diamminedichloridodihydroxoplatinnum(IV) 2 were synthesized according to standard literature procedures.^[1,2] ¹H, ¹³C, ¹⁵N, ¹⁹⁵Pt and two-dimensional TOCSY, HMQC, HSQC, and HMBC NMR spectra were recorded with a Bruker Avance DPX 400 or a Bruker Avance III 500 MHz NMR spectrometer, using the solvent residual peak for ¹H and ¹³C as internal standard. ¹⁵N chemical shifts were referenced relative to external NH₄Cl, whereas ¹⁹⁵Pt chemical shifts were referenced relative to external K₂[PtCl₄]. Half height line widths of ¹⁹⁵Pt resonances are given in parentheses. All infrared spectra were obtained from a KBr matrix (4000-400 cm⁻¹) using a Bruker Vertex 70 FTIR spectrometer. Electrospray ionization mass spectrometry was carried out with a Bruker Esquire 3000 instrument using MeOH as solvent. Elemental analyses were performed using a Perkin-Elmer 2400 CHN-Elemental Analyser by the microlaboratory of the Institute of Physical Chemistry, University of Vienna. The elemental analyses of the ¹⁵N labeled complexes **4** and **6** did not consider the high isotopic purity of the nitrogen. Therefore both, the corrected as well as the measured values are given.

(*OC*-6-33)-Bis(2Z-3-carboxyacrylato)dichlorido(ethane-1,2-diamine)platinum(IV) (3): Maleic anhydride (167.5 mg, 1.708 mmol) was added to a suspension of $enPtCl_2(OH)_2$ (150 mg, 0.417 mmol) in DMF (4 mL) and the reaction mixture was stirred at 70 °C for 3 h. During this time the solid material dissolved to form a brown solution. DMF was then removed under reduced pressure. The residue was dissolved in acetone and filtered to give a clear, light brown solution. This solution was concentrated under reduced pressure, and subsequent addition of diethyl ether led to precipitation of a brown solid. The product was dried in vacuo. Yiel: 120 mg (52%). C₁₀H₁₄Cl₂N₂O₈Pt (556.21): calcd. C 21.59, H 2.54, N 5.04; found C 21.32, H 2.65, 5.19. ESI-MS: m/z 578.9 [M+Na⁺]⁺, 594.9 [M+K⁺]⁺, 555.0 [M–H⁺]⁻. v_{max}(KBr)/cm⁻¹ 3548 (v_{COO-H}), 3200 m, 1698 s, 1657 s, 1623 s, 1542 m, 1381 m, 1050 s, 828 m, 577 m. $\delta_{\rm H}$ (400.13 MHz, d_7 -DMF) 13.49 (bs, 2 H, COO*H*), 8.69 (s, $J_{\rm H,Pt}$ = 52.4 Hz, 4 H, NH₂), 6.96 (d, $J_{\rm H,H}$ = 11.9 Hz, 2 H, 2–H/3–H), 6.24 (d, $J_{\rm H,H}$ = 11.9 Hz, 2 H, 2–H/3–H), 3.38 (bs, 4 H, 5–H). $\delta_{\rm C}$ (100.62 MHz, d_7 -DMF) 173.0, 165.1 (C–1/C–4), 123.3, 133.3 (C–2/C–3), 47.5 (C–5). $\delta_{\rm N}$ (40.55 MHz, d_7 -DMF) –2.8. $\delta_{\rm Pt}$ (86.11 MHz, d_7 -DMF) 2610 (430 Hz).

(*OC*-6-33)-Diamminebis(2Z-3-carboxyacrylato)dichloridoplatinum(IV) (4): The synthesis was carried out as described for 3, but the reaction time was only 1 h. Yield: 97.2 mg (62 %). $C_8H_{12}Cl_2^{15}N_2O_8Pt \cdot 0.5DMF$ (568.71): calcd. C 20.06, H 2.74, N 6.51; found (without consideration of ¹⁵N labeling) C 20.34, H 2.54, N 5.91; found (calcd. with consideration of ¹⁵N labeling) C 20.27, H 2.53, N 6.25. ESI-MS: *m/z* 530.4 [M–H⁺]⁻. $v_{max}(KBr)/cm^{-1}$ 3277 (v_{N-H}), 3130 m, 1692 m, 1620 m, 1576 s, 1525 m, 1485 m, 1301 s, 862 s. $\delta_H(400.13 \text{ MHz}, d_7-DMF)$ 13.74 (bs, 2 H, OH), 6.92 (d, $J_{H,N} = 75.4 \text{ Hz}, J_{H,Pt} = 51.9 \text{ Hz}, 6 \text{ H}, NH_3$), 6.69 (d, $J_{H,H} = 11.9 \text{ Hz}, 2 \text{ H}, 2-\text{H}$), 6.27 (d, $J_{H,H} = 11.9 \text{ Hz}, 2 \text{ H}, 3-\text{H}$). $\delta_C(100.62 \text{ MHz}, d_7-DMF)$ 172.2 ($J_{C,Pt} = 26.1 \text{ Hz}, \text{ C}-1$), 165.3 (C–4), 131.8 ($J_{C,Pt} = 41.5 \text{ Hz}, \text{ C}-2$), 125.5 (C–3). $\delta_N(50.68 \text{ MHz}, d_7-DMF)$ –41.0 (q, $J_{N,H} = 76.3 \text{ Hz}, J_{N,Pt} = 251 \text{ Hz}$). $\delta_{Pt}(107.51 \text{ MHz}, d_7-DMF)$ 2777 (t, $J_{Pt,N} = 252 \text{ Hz}$).

(OC-6-33)-Dichlorido-{N,N'-bis[(4-propylamino)-4-oxobutanoato-2yl]-κ²O,O'-ethane-

1,2-diamine-\kappa^2 N_* N'} platinum(IV) 5: 1,1'-Carbonyldiimidazole (CDI; 132.7 mg, 0.818) mmol) in DMF (8 mL) was added to a solution of **3** (222 mg, 0.399 mmol) in DMF (4 mL) and the mixture was heated to 60 °C. After 10 min stirring, the solution was cooled down to room temperature and CO₂ was removed by flushing with argon. Propylamine (64.5 µL, 0.818 mmol) in DMF (12 mL) was added to the solution and stirred for 24 h at room temperature. DMF was then removed under reduced pressure to form a brown oil. The crude product was purified by column chromatography (EtOAc/MeOH, 6:1) to yield a pale-yellow solid. Yield: 42 mg (16%). C₁₆H₂₈Cl₂N₄O₆Pt (638.40): calcd. C 30.10, H 4.42, N 8.78; found C 30.14, H. 4.48, N 8.67. ESI-MS: m/z 639.1 $[M+H^+]^+$, 661.0 $[M+Na^+]^+$, 677.0 $[M+K^+]^+$, 637.2 $[M-H^+]^-$. v_{max}(KBr)/cm⁻¹3278 (v_{N-H}), 3018 w, 2937 w, 2876 w, 1678, 1647 (v_{as C=O}), 1561 m, 1299 m, 667 w. $\delta_{\rm H}(400.13 \text{ MHz}, d_7\text{-DMF})$ 10.05 (m, $J_{\rm H,Pt}$ = 44.5 Hz, 2 H, C-8–NH), 8.22 (m, 2 H, C-4-NH), 4.75 (dd, $J_{H,H}$ = 10.8 Hz, $J_{H,Pt}$ = 36 Hz, 2 H, 2-H), 4.04 (dd, $J_{H,H}$ = 9.6 Hz, $J_{H,Pt}$ = 37.4 Hz, 2 H, 8–H), 3.51 (m, 2 H, 3–H), 3.40 (m, 2 H, 8–H), 3.32 (m, 4 H, 5–H), 3.04 (m, 2 H, 3–H), 1.67 (m, 4 H, 6–H), 1.06 (t, $J_{H,H}$ = 7.4 Hz, 6 H, 7–H). $\delta_{C}(100.62 \text{ MHz}, d_{7}\text{-DMF})$ 182.4 (C-1), 167.2 (C-4), 62.4 (C-2), 56.6 (C-8), 39.6 (C-5), 38.0 (C-3), 21.0 (C-6), 9.5 (C-7). δ_N(40.55 MHz, d₇-DMF) 94.8 (C-4-NH), 21.0 (C-8-NH). δ_{Pt}(86.11 MHz, d₇-DMF) 2224 (332 Hz).

(OC-6-54)-Amminedichlorido(2R,2S-imino-ĸN-bis[(4-propylamino)-4-oxobutanoato-

2yl]-\kappa^2 O, O')platinum(IV) (6): The synthesis was carried out as described for **5**. The crude product was first purified by column chromatography (EtOAc/MeOH, 5:1); afterwards, the pure product was obtained via vapor diffusion of diethyl ether into a solution of **6** in acetone. Yield: 15.3 mg (7 %). C₁₄H₂₆¹⁵N₂N₂O₆Pt (614.35): calcd. C 27.37, H 4.27, N 9.44; found

(without consideration of ¹⁵N labeling ¹⁵N) C 27.58, H 4.30, N 8.95; found (calcd. with consideration of ¹⁵N labeling) C 27.49, H 4.29, N 9.27. ESI-MS: *m*/z 637.3 [M+Na⁺]⁺, 613.2 [M–H⁺]⁻. v_{max}(KBr)/cm⁻¹ 3344 m, 3272 w, 3046 m, 2970 w, 2880 w, 1696, 1638 (v_{as C=O}), 1571 m, 1225 m, 870 w. $\delta_{\rm H}(500.32 \text{ MHz}, d_7\text{-DMF})$ 9.87 (dt, $J_{\rm H,\rm H}$ = 8.6 Hz, $J_{\rm H,\rm N}$ = 77.9 Hz, $J_{\rm H,\rm Pt}$ = 55.9 Hz, 1 H, C–2–N*H*), 8.64 (t, $J_{\rm H,\rm H}$ = 5.5 Hz, 2 H, C–4–N*H*), 6.77 (d, $J_{\rm H,\rm N}$ = 74.3 Hz, $J_{\rm H,\rm Pt}$ = 49.5 Hz, 3 H, N*H*₃), 4.90 (m, 2 H, 2–H), 3.33 (m, 2 H, 3–H), 3.27 (m, 4 H, 5–H), 3.25 (m, 2 H, 3-H), 1.63 (m, 4 H, 6–H), 1.03 (t, $J_{\rm H,\rm H}$ = 7.4 Hz, 6 H, 7–H). $\delta_{\rm C}(125.81 \text{ MHz}, d_7\text{-DMF})$ 179.9 (d, $J_{\rm C,\rm N}$ = 1.8 Hz, 1–C), 169.4 (4–C), 63.1 (d, $J_{\rm C,\rm N}$ = 4.0 Hz, 2–C), 39.5 (5–C), 35.5 (3–C), 21.0 (6–C), 9.6 (7–C). $\delta_{\rm N}(50.68 \text{ MHz}, d_7\text{-DMF})$ 0.3 (d, $J_{\rm N,\rm H}$ = 78.1 Hz, $J_{\rm N,\rm Pt}$ = 215 Hz, 1 N, C–2–*N*H), -31.3 (q, $J_{\rm N,\rm H}$ = 74.4 Hz, $J_{\rm N,\rm Pt}$ = 277 Hz, 1 N, *N*H₃). $\delta_{\rm Pt}(107.55 \text{ MHz}, d_7\text{-DMF})$ 2302 (dd, $J_{\rm Pt,\rm N}$ = 274 Hz, $J_{\rm Pt,\rm N}$ = 218 Hz)

Selected NMR spectra of complex 5



Figure S1. ¹H–¹H TOCSY NMR spectrum of complex **5**.



Figure S2. $^{1}H^{-13}C$ HMQC NMR spectrum of complex 5.

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Figure S3. $^{1}H^{-13}C$ HMBC NMR spectrum of complex **5**.



Figure S4. ¹H–¹⁵N HMQC NMR spectrum of complex **5**.

ppm

Figure S5. ¹⁹⁵Pt NMR spectrum of complex 5.





Figure S6. $^{1}H^{-1}H$ COSY NMR spectrum of complex 6.

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Figure S7. $^{1}H^{-1}H$ TOCSY NMR spectrum of complex 6.



Figure S8. $^{1}H^{-13}C$ HSQC NMR spectrum of complex 6.

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Figure S9. $^{1}H^{-13}C$ HMBC NMR spectrum of complex 6.



Figure S10. ¹⁹⁵Pt{¹H} NMR spectrum of complex **6**.

References

- 1 E. J. Bulten and F. Verbeek, U.S. Patent 4482569, 1984.
- 2 C. Dhara, Ind. J. Chem., 1970, 8, 193.