Supporting Information

Synthesis of N-heterocyclic carbene gold(I) complexes from the marine betaine 1,3-dimethylimidazolium-4-carboxylate

Contents

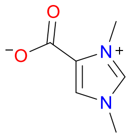
General

Materials and analytical methods

All starting materials were commercially available and were purchased from Aldrich, Wako. Au(SMe$_2$)Cl was prepared according to the literature.[1] All reactions were carried out under air and technical grade solvents were used unless otherwise stated. K_2CO_3 was used as received without further purification. ^{1}H and ^{13}C NMR spectra were measured on the spectrometers Bruker AV 300 (300 MHz) and AV 500 (500 MHz) spectrometers. Chemical shifts are given in parts per million (δ; ppm) relative to residual solvent peaks (δ; 3.31 (CD_3OD), 4.79 (D_2O). Coupling constants (*J*) are reported in Hertz (Hz), and splitting patterns are indicated as s (*singlet*), d (*doublet*), t (*triplet*), m (*multiplet*), sept (*septet*) and br (*broad*). All spectra were measured at room temperature unless otherwise stated. Elemental analysis of all the complexes was performed using a Vario Micro Cube System (Elementar Analysensysteme GmbH). High and low resolution electrospray ionization (ESI) measurements were performed on a Bruker MicroTOF II mass spectrometer. Analytical thin layer chromatography (TLC) was carried out on EMD 250 micron 60 F254 silica gel plates, visualized with UV light and stained with a *p*-anisaldehyde solution.

Experimental procedures

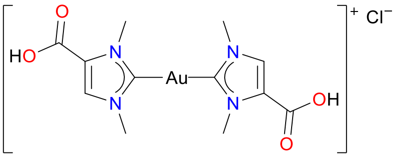
Synthesis of Norzooanemonine (1)



1-Methylimidazole (2.95 g, 36 mmol) and dimethyl carbonate (3.24 g, 36 mmol) were placed into a bomb flask. After stirring at 140 °C for 8 hours, a yellowish mixture was obtained, which was washed with cold methanol to give a white powder. Yield: 3.54 g (70.2%).

^{1}H NMR (D_2O, 300.1 MHz): δ = 8.64 (s, 1H), 7.72 (s, 1H), 4.01 (s, 3H), 3.88 (s, 3H) ppm. $^{13}C\{^1H\}$ NMR (D_2O, 75.5 MHz): δ = 166.3 (s, *C*OO), 133.5 (s, N*C*COO), 129.1 (s, N*C*HC), 125.9 (s, N*C*HN), 39.5 (s, *C*H$_3$), 38.4 (s, *C*H$_3$) ppm. Elemental analysis (%): calcd for $C_6H_8N_2O_2$ (140.14): C 51.42, H 5.75, N 19.99; found: C 50.20, H 6.23, N 19.83.

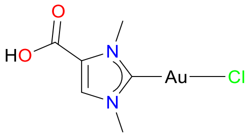
Synthesis of compound (2)



At room temperature, **1** (0.140 g, 1 mmol) was stirred for 3 hours with K_2CO_3 (0.138 g, 1 mmol) in methanol, then Au(SMe$_2$)Cl (0.147 g, 0.5 mmol) was added and the mixture was stirred overnight. After filtering the purple mixture and removing the solvent *in vacuo*, a pale yellow solid was obtained. The latter was washed with methanol to give a white solid that cannot be separated from KCl and $KHCO_3$ due to its high water solubility. The crude product was dissolved in water (15 mL) and treated with HCl (aqueous, 2 N) to reach a pH value of 1-2, at which point a white powder precipitated. The subsequent precipitate was filtered, washed with water and dried to afford compound **2**. Yield: 0.154 g (60.1%).

^{1}H NMR (CD_3OD, 500.3 MHz): δ = 8.01 (s, 1H), 4.17 (s, 3H), 3.95 (s, 3H) ppm. ^{13}C{^{1}H} NMR (CD_3OD, 125.8 MHz): δ = 189.6 (s, *C*-Au), 161.4 (s, *C*OO), 130.7 (s, N*C*HC), 126.8 (s, N*C*COO), 38.6 (s, *C*H$_3$), 38.4 (s, *C*H$_3$) ppm. Elemental analysis (%): calcd for $C_{12}H_{16}AuClN_4O_4$ (512.70): C 28.11, H 3.15, N 10.93; found: C 28.53, H 3.21, N 11.28. ESI-MS *m/z* anion: calculated for $[M - Cl]^+$ 477.08; Found $[M - Cl]^+$ 477.12 m/z.

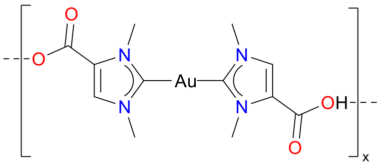
Synthesis of compound (3)



Au(SMe_2)Cl (0.073 g, 0.25 mmol) was added to a stirred solution of compound **2** (0.129 g, 0.25 mmol) in methanol (10 mL). After stirring for 4 hours at room temperature, the mixture turned brown. After filtration through Celite, the solvent was removed *in vacuo* to afford compound **3** as a white solid. Yield: 0.079 g (85.0 %).

^{1}H NMR (CD_3OD, 300.1 MHz): δ = 7.92 (s, 1H), 4.07 (s, 3H), 3.84 (s, 3H) ppm. ^{13}C{^{1}H} NMR (CD_3OD, 75.5 MHz): δ = 176.6 (s, *C*-Au), 161.4 (s, *C*OO), 130.2 (s, N*C*HC), 126.1 (s, N*C*COO), 38.8 (s, *C*H$_3$), 38.5 (s, *C*H$_3$) ppm. Elemental analysis (%): calcd for $C_6H_8AuClN_2O_2$ (372.56): C 19.34, H 2.16, N 7.52; found: C 19.13, H 2.03, N 7.10. ESI-MS *m/z* anion: calculated for $[M - H]^-$ 370.99; Found $[M - H]^-$ 370.68 m/z.

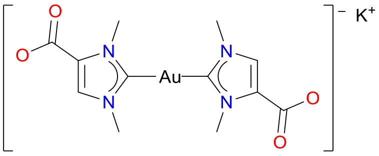
Synthesis of compound (4)



After stirring the mixture of **1** (0.140 g, 1 mmol) and K_2CO_3 (0.138 g, 1 mmol) in methanol for 3 hours at room temperature, Au(SMe_2)Cl (0.147 g, 0.5 mmol) was added and the reaction was stirred overnight. After filtration of the purple mixture and removal of the solvent under vacuum, a pale yellow solid was obtained. The solid material was washed with methanol to give a white powder which could not be separated from KCl and $KHCO_3$. The powder was dissolved in water (15 mL) and treated with HI (aqueous, 2 N) to reach a pH value between 6-7, resulting in the precipitation of a white powder. After filtration and washing with water, the white powder was dried to give compound **4**. Yield: 0.112 g (47.0 %).

^{1}H NMR (CD_3OD, 500.3 MHz): δ = 7.58 (s, 1H), 4.16 (s, 3H,), 3.89 (s, 3H) ppm. ^{13}C{^{1}H} NMR (CD_3OD, 125.8 MHz): δ = 187.8 (s, *C*-Au), 127.4 (s, N*C*HC), 38.3 (s, *C*H$_3$), 38.1 (s, *C*H$_3$) ppm, due to low solubility ^{13}C resonances for (s, *C*OO) and (s, N*C*COO) were not observed. Elemental analysis (%): calcd for $C_{12}H_{15}AuN_4O_4$ (476.24): C 30.26, H 3.17, N 11.76; found: C 29.90, H 3.201, N 11.64. ESI-MS *m/z* anion: calculated for $[M + H]^+$ 477.08; Found $[M + H]^+$477.14 m/z and calculated for $[M + Na]^+$ 499.07; Found $[M + Na]^+$ 499.04 m/z

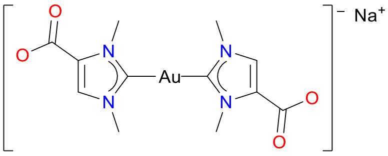
Synthesis of compound (5^K)



One equivalent of KOH was added to an aqueous solution of compound **4** (0.114 g, 0.24 mmol, 15 ml H_2O) and the reaction mixture was stirred for 30 min. The solvent was then removed in a rotary evaporator to give a white powder, which was then washed with acetone to remove any traces of KI and dried under vacuum to afford compound **5^K**. This compound contains water molecules which co-crystallize according to its crystal structure. Yield: 0.114 g (92.3%).

^{1}H NMR (D_2O, 300.1 MHz): δ = 7.44 (s, 1H), 3.94 (s, 3H), 3.68 (s, 3H) ppm. ^{13}C{^{1}H} NMR (D_2O, 75.5 MHz): δ = 188.8 (s, *C*-Au), 167.4 (s, *C*OO), 133.1 (s, N*C*COO), 129.6 (s, N*C*HC), 40.1 (s, *C*H$_3$), 40.0 (s, *C*H$_3$) ppm. Elemental analysis (%): calcd for $C_{12}H_{14}AuKN_4O_4.H_2O$ (532.33): C 27.07, H 3.03, N 10.52; found: C 27.02, H 2.89, N 10.24. ESI-MS *m/z* anion: calculated for $[M + H]^+$ 515.04; Found $[M + H]^+$514.96 m/z.

Synthesis of compound (5Na)



An aqueous solution of compound **4** (0.114 g, 0.24 mmol, 15 ml H_2O) was stirred for 30 minutes with 1 equivalent of NaOH. After drying in a rotary evaporator, a white powder was obtained. It was then washed with acetone to remove any traces of NaI and dried under vacuum to give compound **5Na**. According to its elemental analysis, water is co-crystallized. Yield: 0.110 g (92.0%).

^{1}H NMR (D_2O, 300.1 MHz): δ = 7.39 (s, 1H), 3.89 (s, 3H), 3.63 (s, 3H) ppm. ^{13}C{^{1}H} NMR (D_2O, 75.5 MHz): δ = 188.7 (s, *C*-Au), 167.3 (s, *C*OO), 133.1 (s, N*C*COO), 129.5 (s, N*C*HC), 40.0 (s, *C*H$_3$), 39.9 (s, *C*H$_3$) ppm. Elemental analysis (%): calcd $C_{12}H_{14}AuNaN_4O_4\bullet H_2O$ (516.22): C 27.92, H 3.12, N 10.85; found: C 27.35, H 2.90, N 10.40. ESI-MS *m/z* anion: calculated for $[M + Na]^+$ 521.05; Found $[M + Na]^+$521.02 m/z.

NMR and other spectra

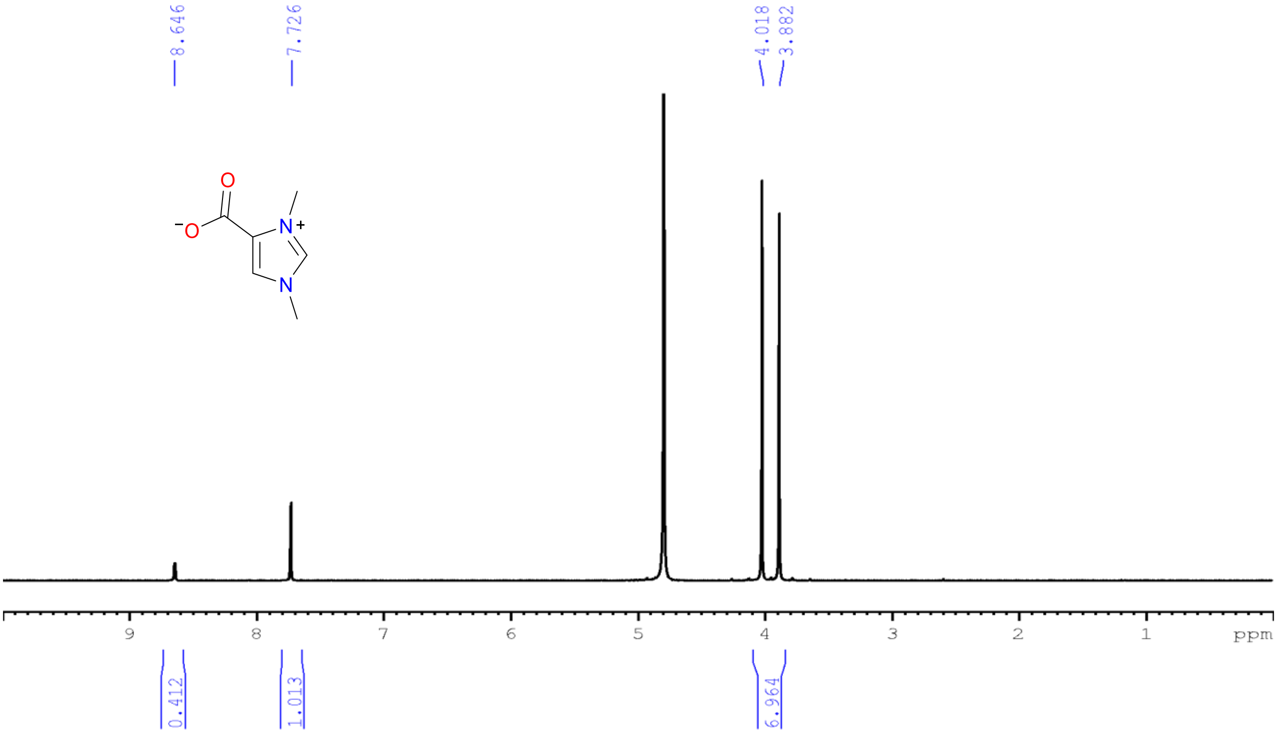


Figure S1. ^{1}H NMR spectrum of (**1**) in D_2O at room temperature.

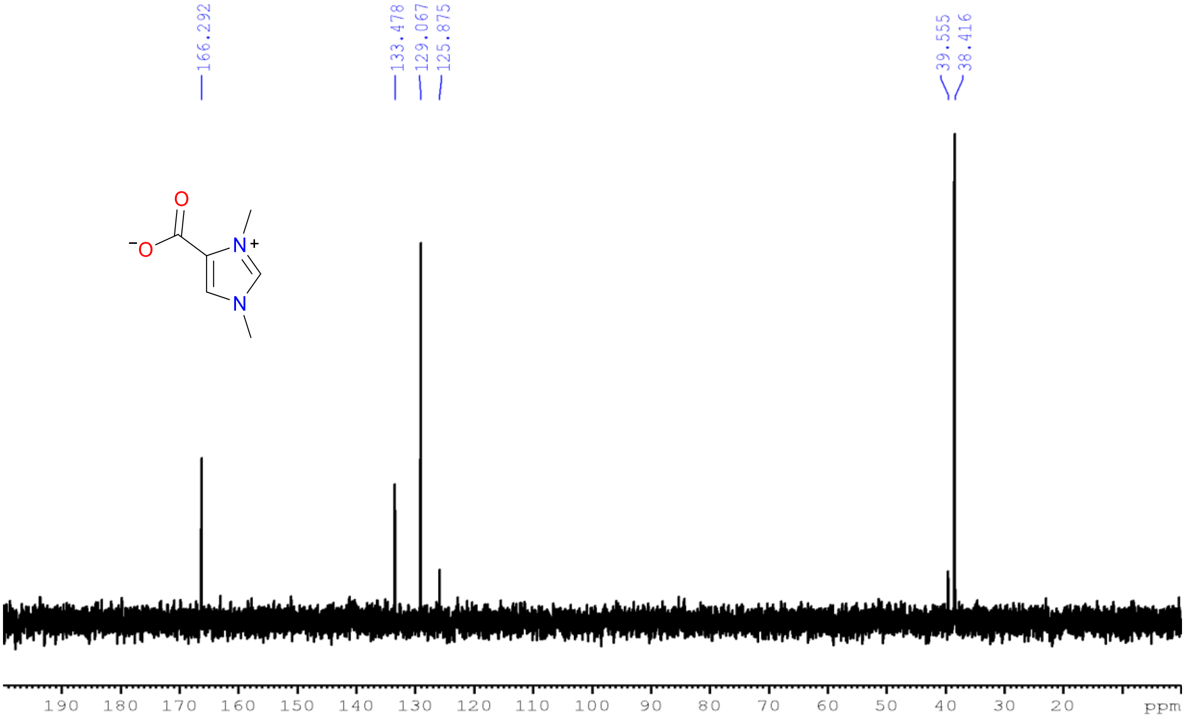


Figure S2. $^{13}C\{^{1}H\}$ NMR spectrum of (**1**) in D_2O at room temperature.

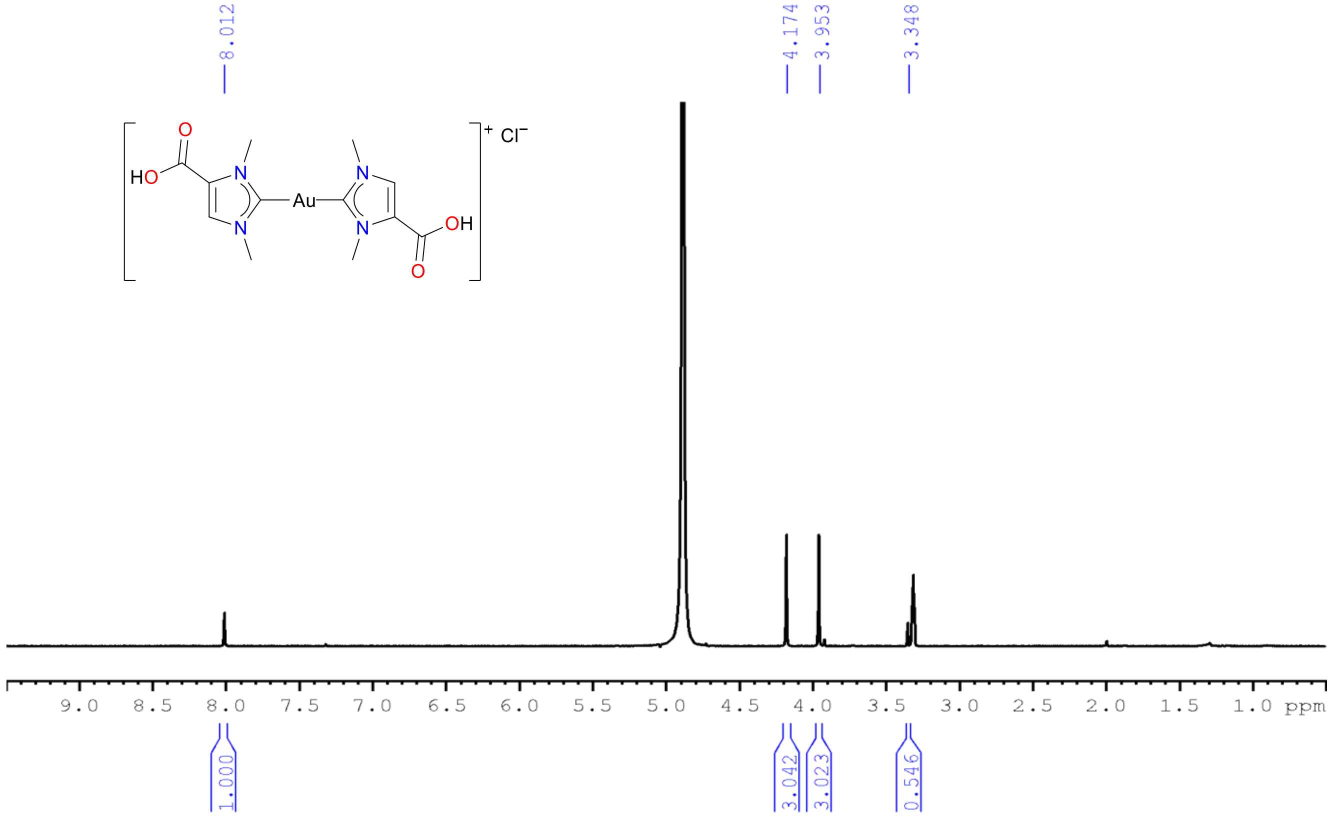


Figure S3. ^{1}H NMR spectrum of (**2**) in CD_3OD at room temperature.

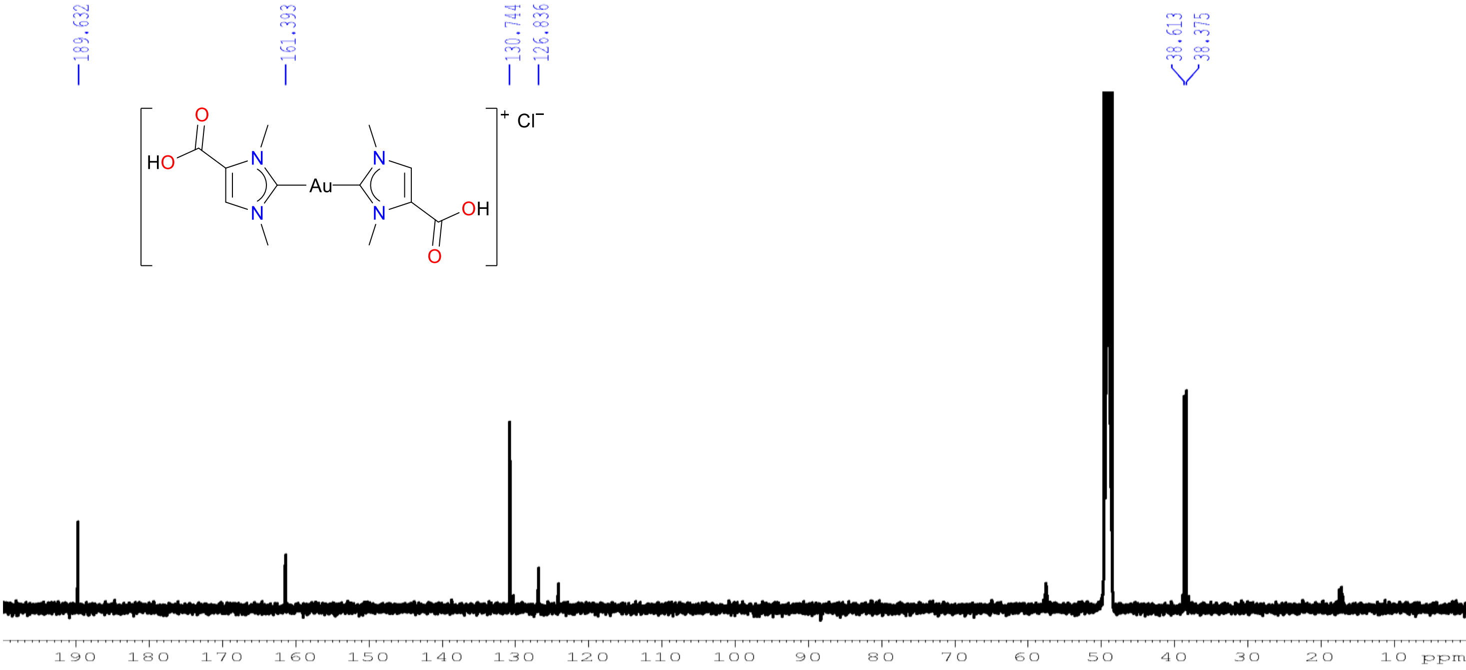


Figure S4. $^{13}C\{^1H\}$ NMR spectrum of (**2**) in CD_3OD at room temperature.

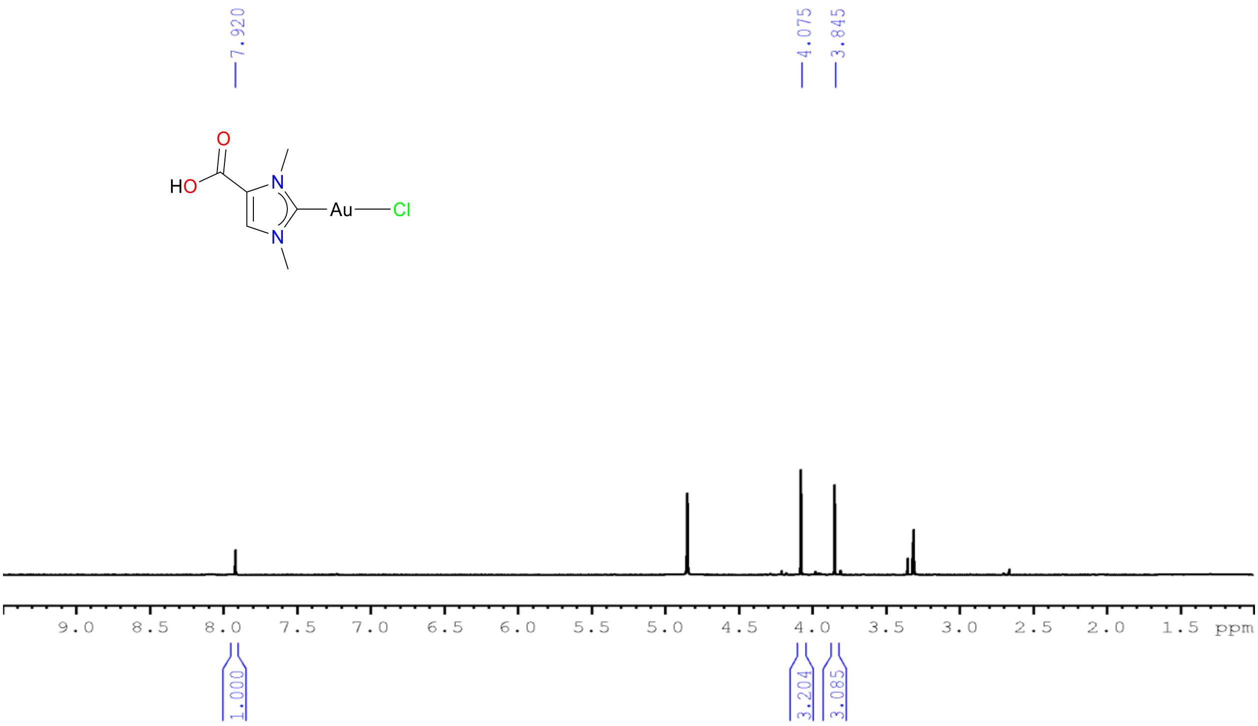


Figure S5. ^{1}H NMR spectrum of (**3**) in CD_3OD at room temperature.

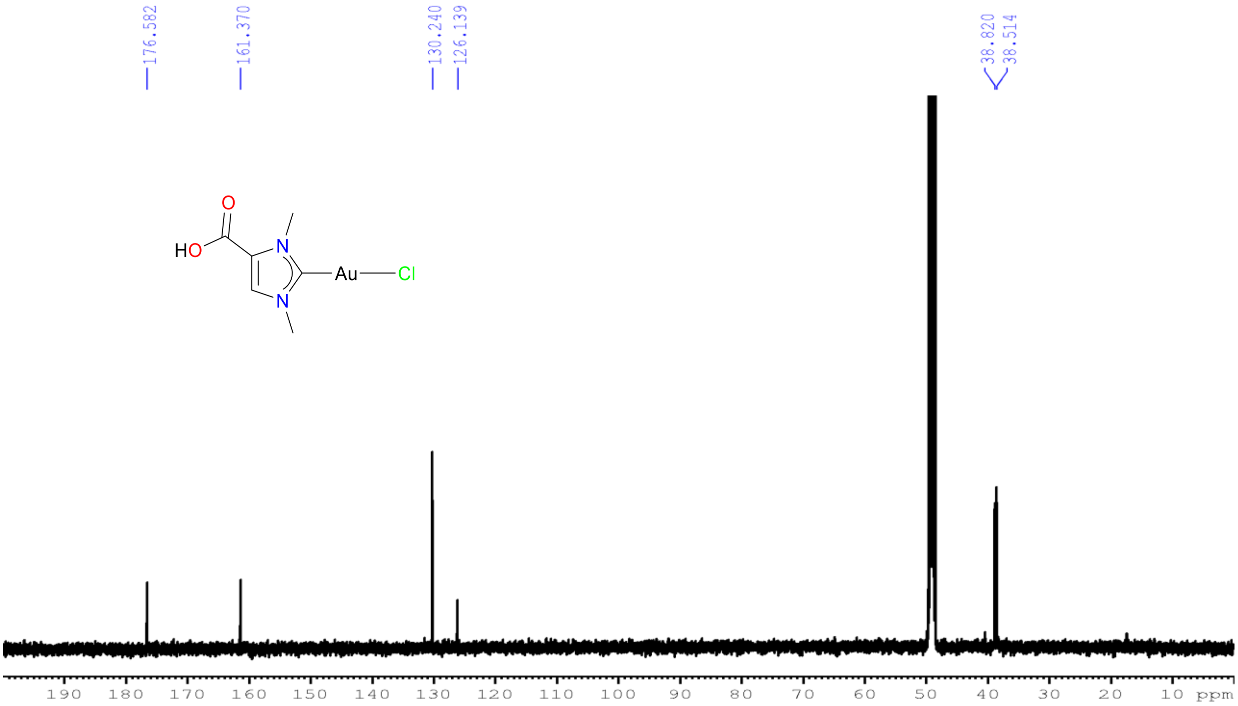


Figure S6. $^{13}C\{^{1}H\}$ NMR spectrum of (**3**) in CD_3OD at room temperature.

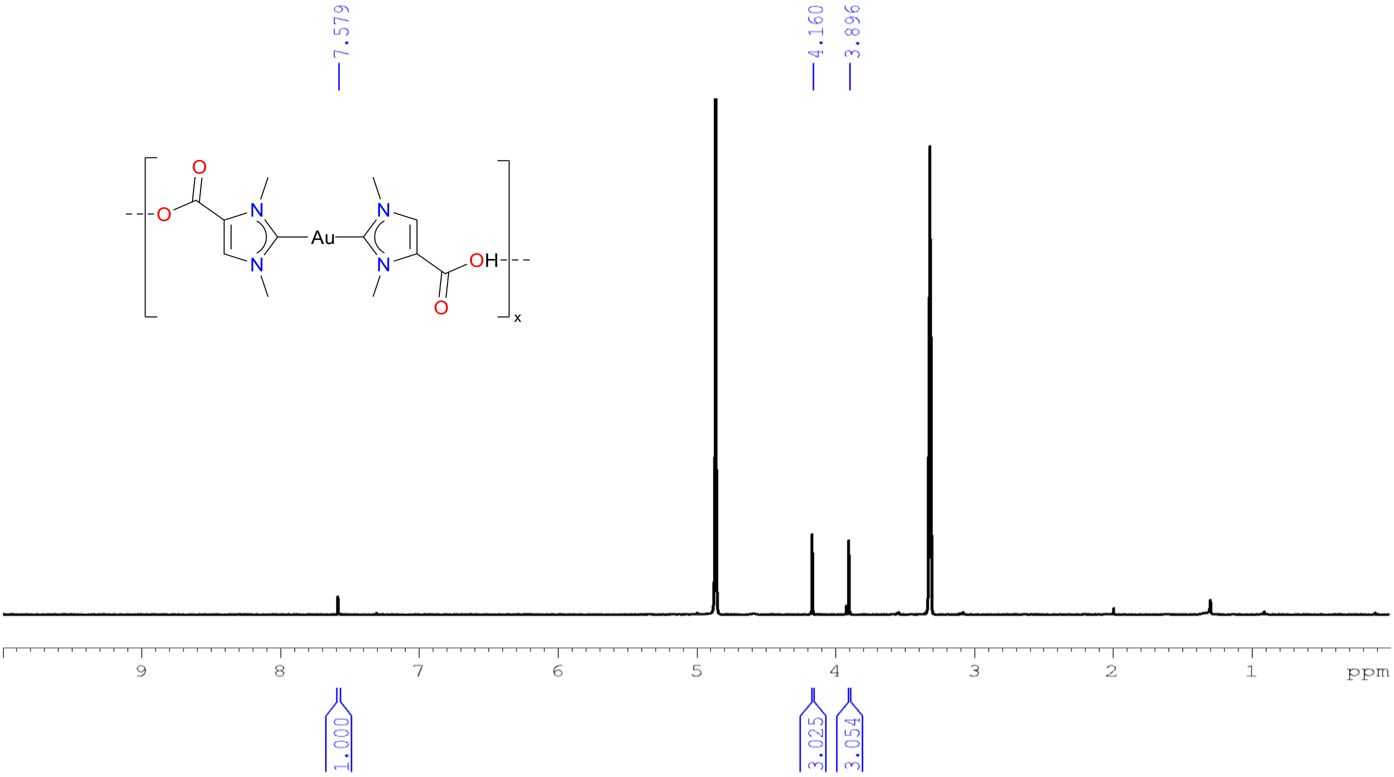


Figure S7. ^{1}H NMR spectrum of (**4**) in CD_3OD at room temperature.

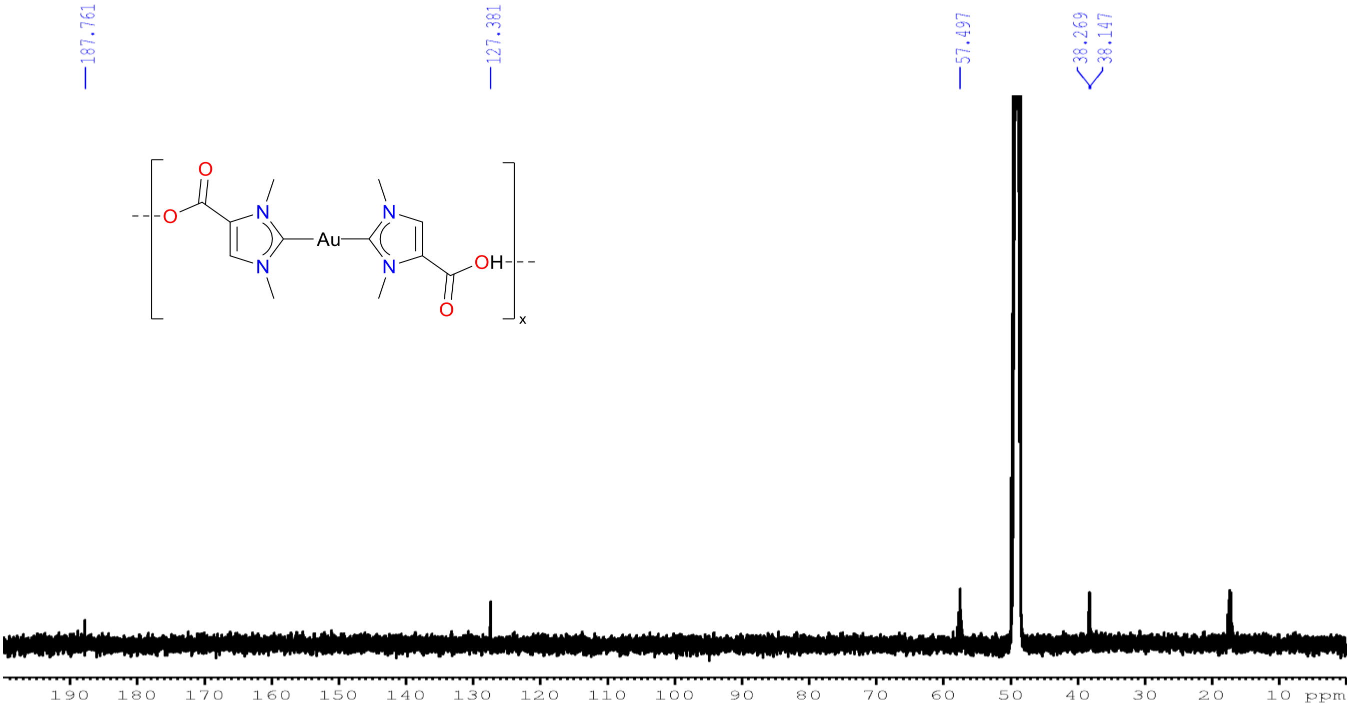


Figure S8. $^{13}C\{^1H\}$ NMR spectrum of (**4**) in CD_3OD at room temperature.

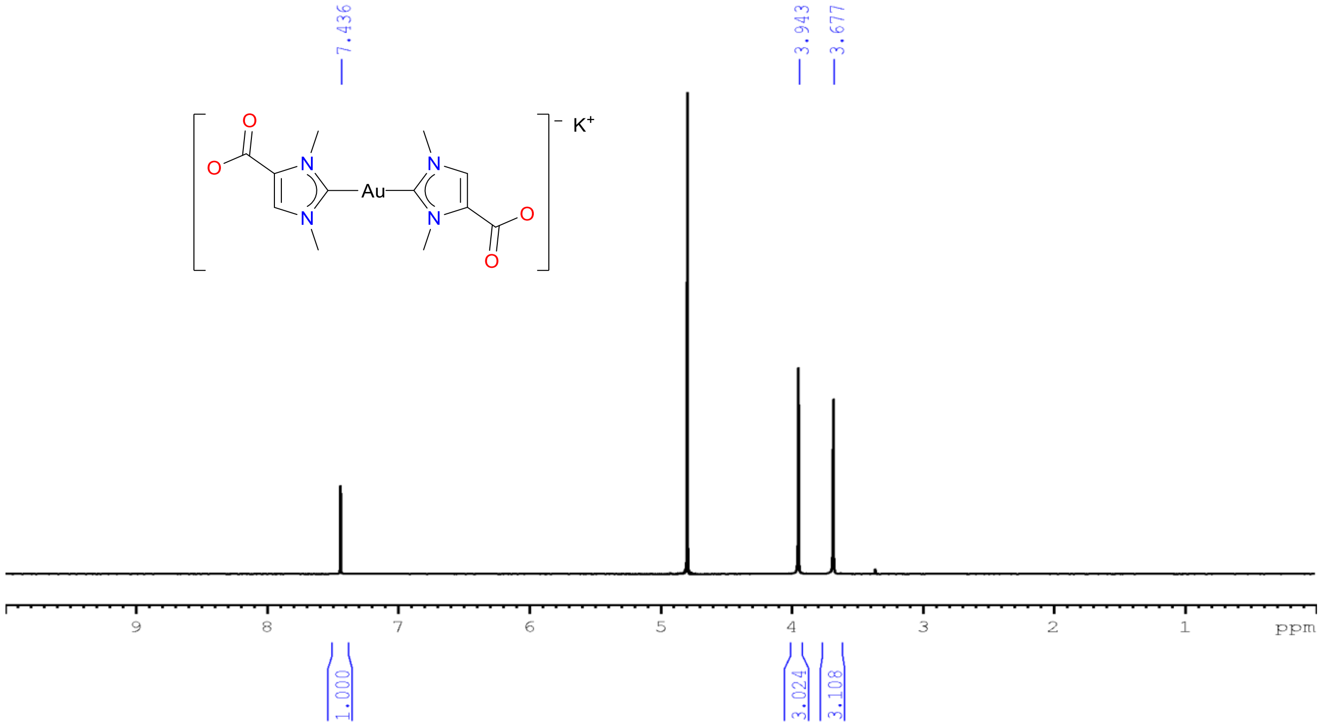


Figure S9. ^{1}H NMR spectrum of (**5**^{K}) in D_2O at room temperature.

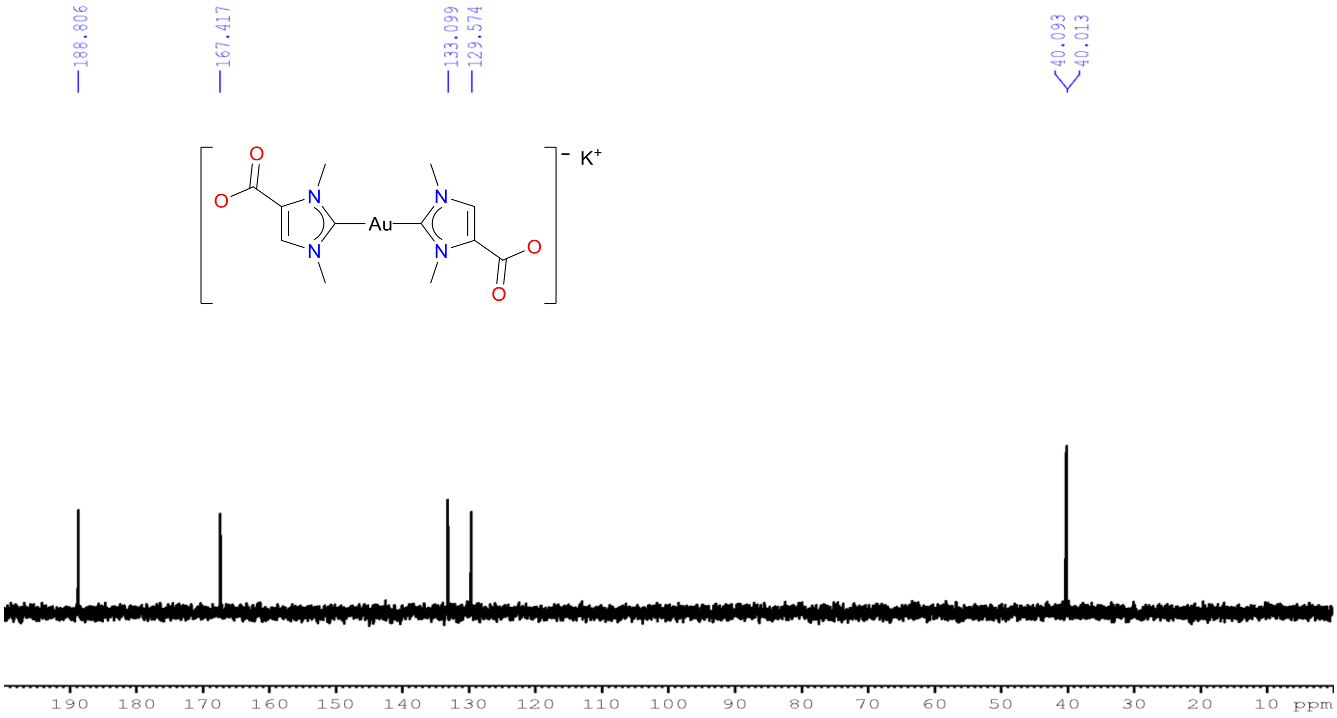


Figure S10. $^{13}C\{^1H\}$ NMR spectrum of (**5**^{K}) in D_2O at room temperature.

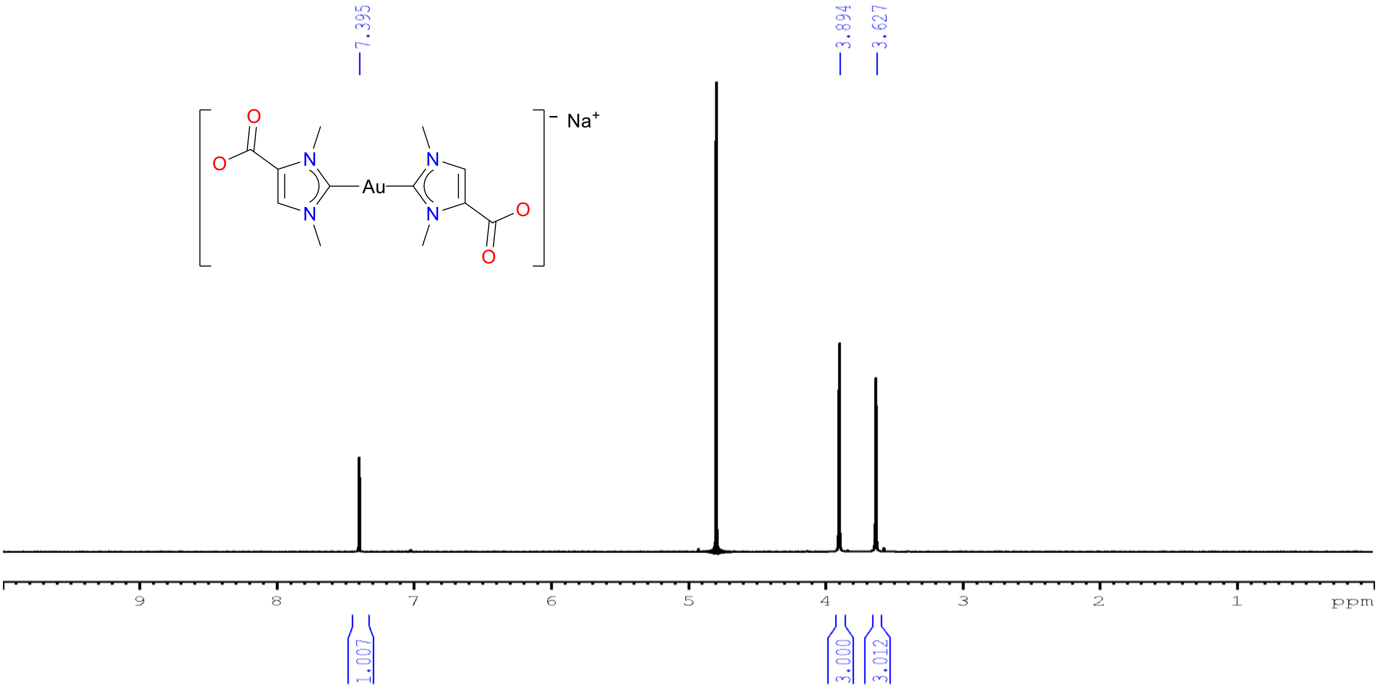


Figure S11. ^1H NMR spectrum of (**5**^{Na}) in D_2O at room temperature.

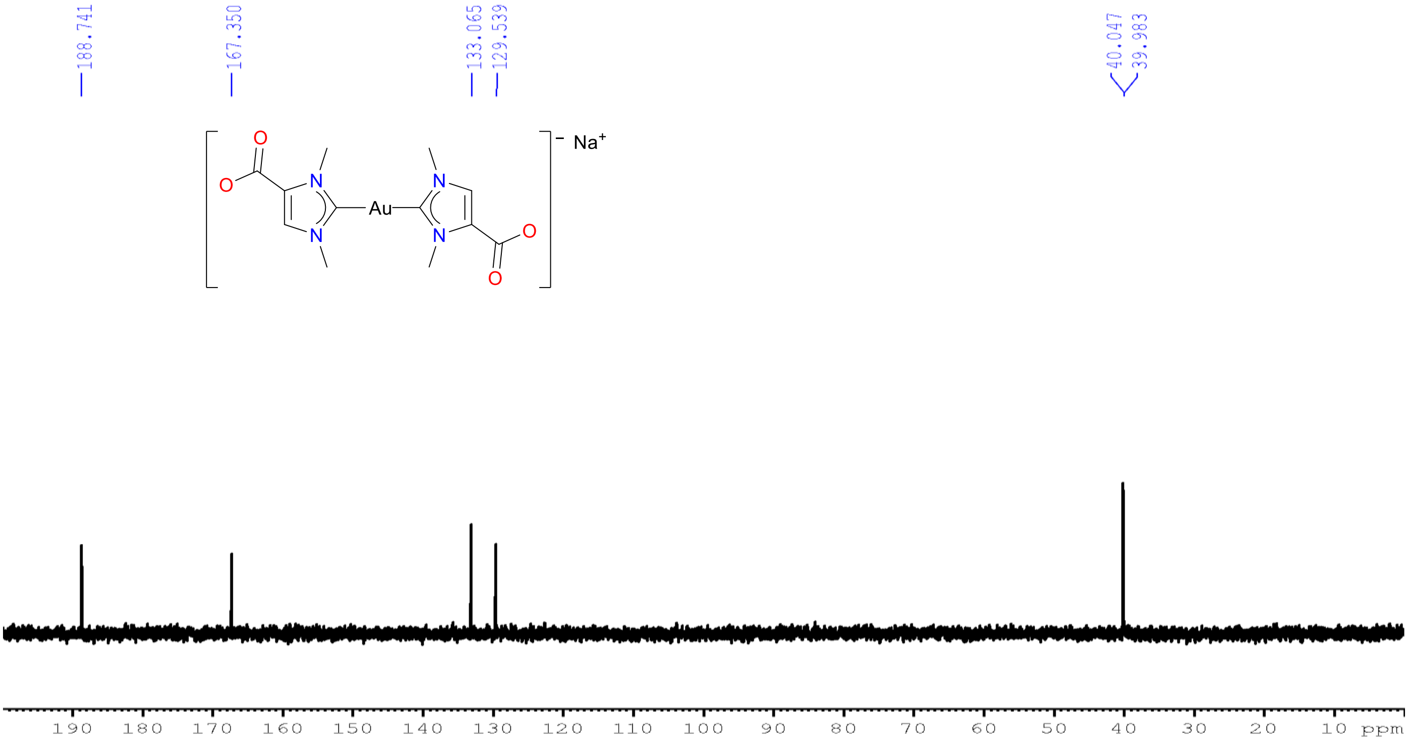


Figure S12. $^{13}C\{^1H\}$ NMR spectrum of (**5**^{Na}) in D_2O at room temperature.

Single crystal X-ray diffraction

Crystals were mounted on top of a human hair or on a Hampton Research CryoLoop™ with per-fluorinated inert oil. Data were recorded on Rigaku XtaLAB Synergy S Single Source diffractometers equipped with a HyPix-6000HE detector and a PhotonJet microfocus source with Cu-Kα (**1**·2 H_2O**,** **1**·MeOH, **2**·H_2O, **4**·6H_2O**,** **5**$^{\mathbf{K}}$·2H_2O·MeOH) or Mo-Kα (**3**, **5**$^{\mathbf{K}}$·4H_2O) radiation. Data reduction was performed with CrysalisPro[2]. Absorption correction was based on multi-scans and for compounds **1**·MeOH, **3**, **5**$^{\mathbf{K}}$·2H_2O·MeOH, **5**$^{\mathbf{K}}$·4H_2O additionally face indexation and integration on a Gaussian grid was applied. The structure of compound **2**·H_2O was solved with the Patterson method with SHELXS-2013/1[3] whereas all other structures were solved by intrinsic phasing with SHELXT-2018/2[4] and Refinements are based on F^2 using the program SHELXL-2018/3 [5] in OLEX^2 [6]. The hydrogen atoms of the water molecules in **1**·2 H2O and the hydrogen atom on the methanol OH group in **1**·MeOH have been refined freely. All other hydrogen atoms were placed in idealized positions and refined using a riding model.

The structure of compound **1**·2 H_2O was refined as a non-merohedral 2-component twin with component 2 rotated by 175.7235° around the *b* axis. The simulated precession image of the H0L plane (Figure S13) indicates a second component. Even though the reflections for the second component are rather weak and ignoring these reflections would lead to better refinement indicators, this structure was refinement as a twin.

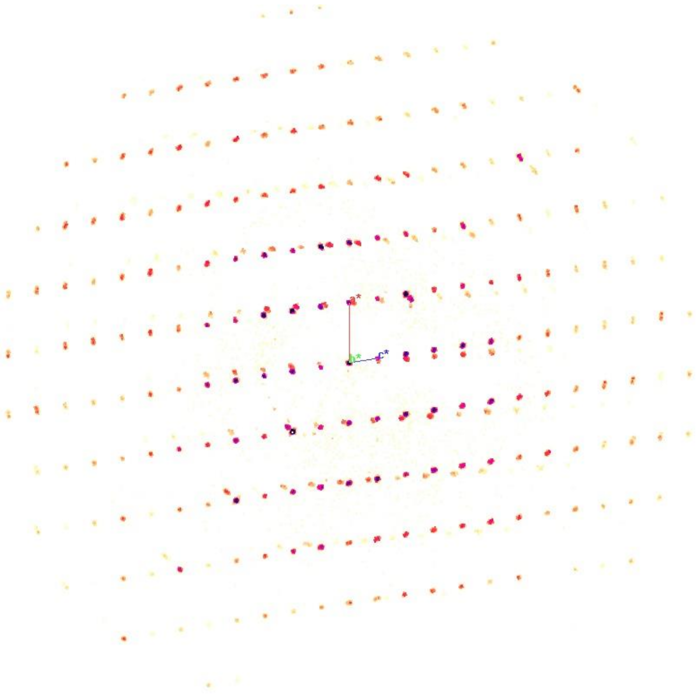


Figure S13. Simulated precession Image of the H0L plane; generated with Ewald3D[2](Offset 0, Slice Margin 3).

For data reduction on compound **2**·H_2O the first runs and some sunburst frames were skipped. In these initial data a second component with different cell parameters (doubled a axis) and a different orientation was present but the corresponding reflections are missing in the following runs. Possibly a small fragment of the crystal was removed by the N_2 stream or phase transition took place during the during the first part of the experiment. The Cl atom was refined with a disorder model with one Cl atom and a molecule of water with occupancies of 50 % each. Restraints on their thermal displacement parameters were applied.

The observed reflections for structure **4**·6H_2O were relatively broad. This was taken into account during the data reduction by overriding the peak integration mask sizes by factor 2.00. Because of the low data resolution, no hydrogen atoms have been refined freely.

The crystal structure of **5**^{K}·2H_2O·MeOH suffers from poor resolution. Despite several attempts only very small crystals were obtained from this compound. Even with Cu-Kα radiation only very weak and poorly resolved datsets were obtained. Additionally, the simulated precession image of the 0KL plane shows very broad partially ringlike peaks, which may result from unresolved twinnig and/or low crystallinity. High residual electron densities around the gold atom are observed. Figure S14 illustrates the extent of the issues. Accordingly, this structure is verifying the connectivity of the given compound and its composition but is not suitable for deriving metric parameters.

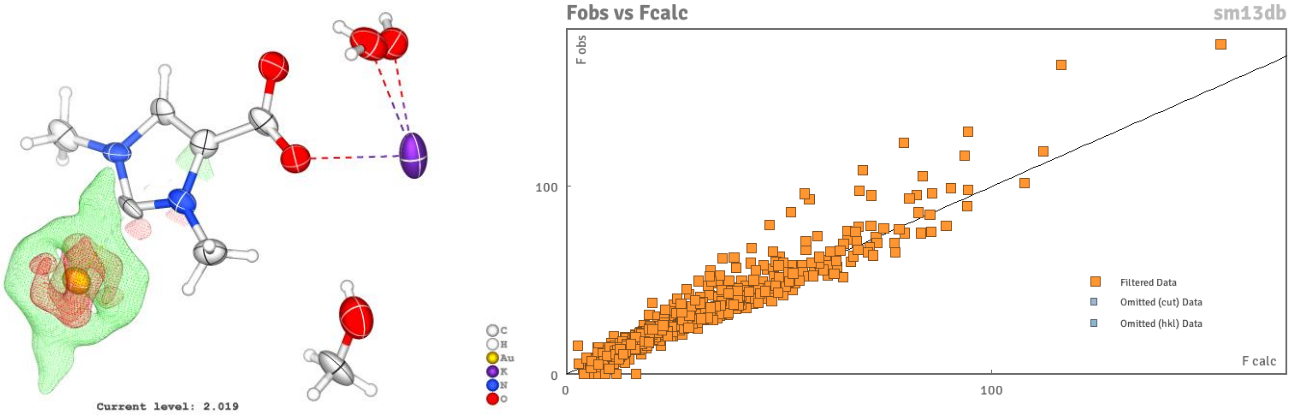


Figure S14. Left: Plot showing the residual density around the gold atom in **5**^{K}·2H_2O·MeOH (Largest diff. peak 8.532 e·Å^{-3}); Right: Fobs vs Fcalc plot for **5**^{K}·2H_2O·MeOH.

Some water molecules as well as the potassium atom in the structure of **5**^{K}·4H_2O were found disordered. The structure was refined as a non-merohedral 2-component twin. With the second component rotated by 179.6494° around the *b* axis.

Crystal structure of 1:

Compound **1** was previously reported as monohydrate by R. Rogers[7]. Beside this structure we found two more solvates of this compound during our work, the dihydrate and the methanol solvate **1**·2 H_2O and **1**·MeOH (table S1 and S2). In **1**·2 H_2O the main molecules are connectedto planes via hydrogen bonding (O4-H4E···O2, O1···H3B-O3, O3···H4D-O4 and C1-H1···O2), whereas these planes are connected by the hydrogen bonds between O3-H3a···O4 (see Figure S15). The structure of **1**·MeOH is formed by a classic hydrogen bond (O3-H3A···O2) and some relatively long hydrogen contacts, C5-H5···O3, C1-H1···O2 and C5-H5B···O1 with O···H distances of 2.5309(7), 2.2073(8) and 2.4579(8) Å respectively (see Figure S16).

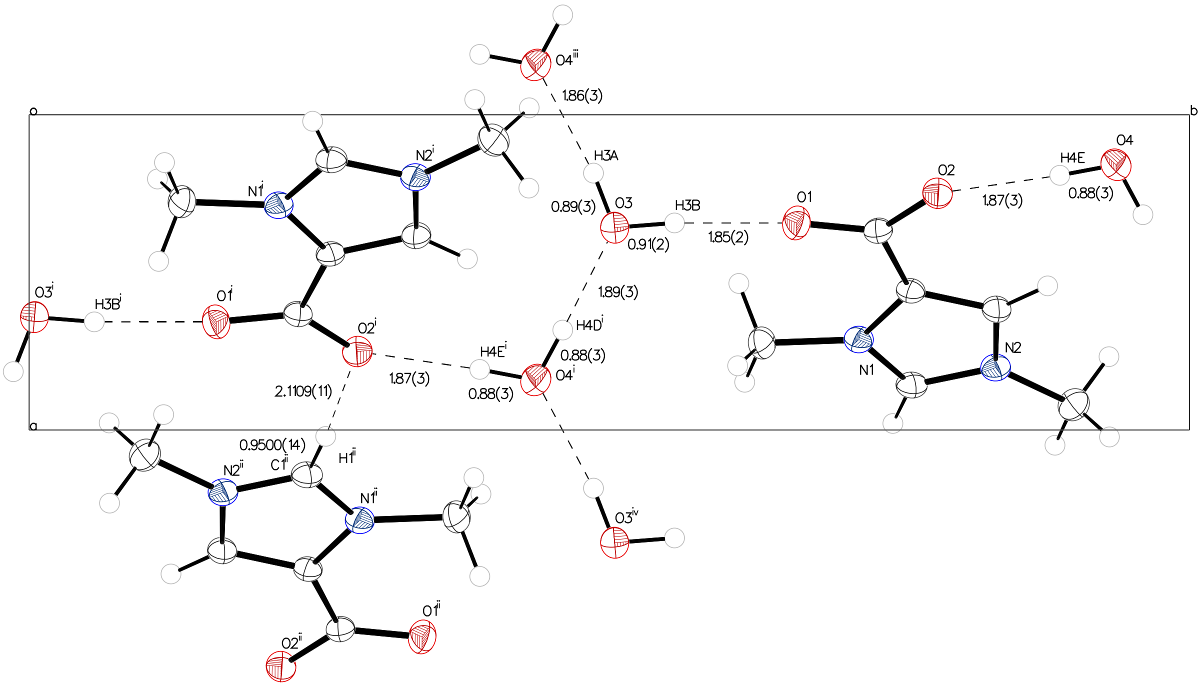


Figure S15. Packing diagram of **1**·2 H_2O; view along the *c* axis, distances are given in Å. Molecules were generated by the following operations: i) 1-x, ½+y, 1½-z; ii) 2-x, 1-y, 1-z; iii) -x, -½+y, 1½-z; iv) 1+x, +y, +z.

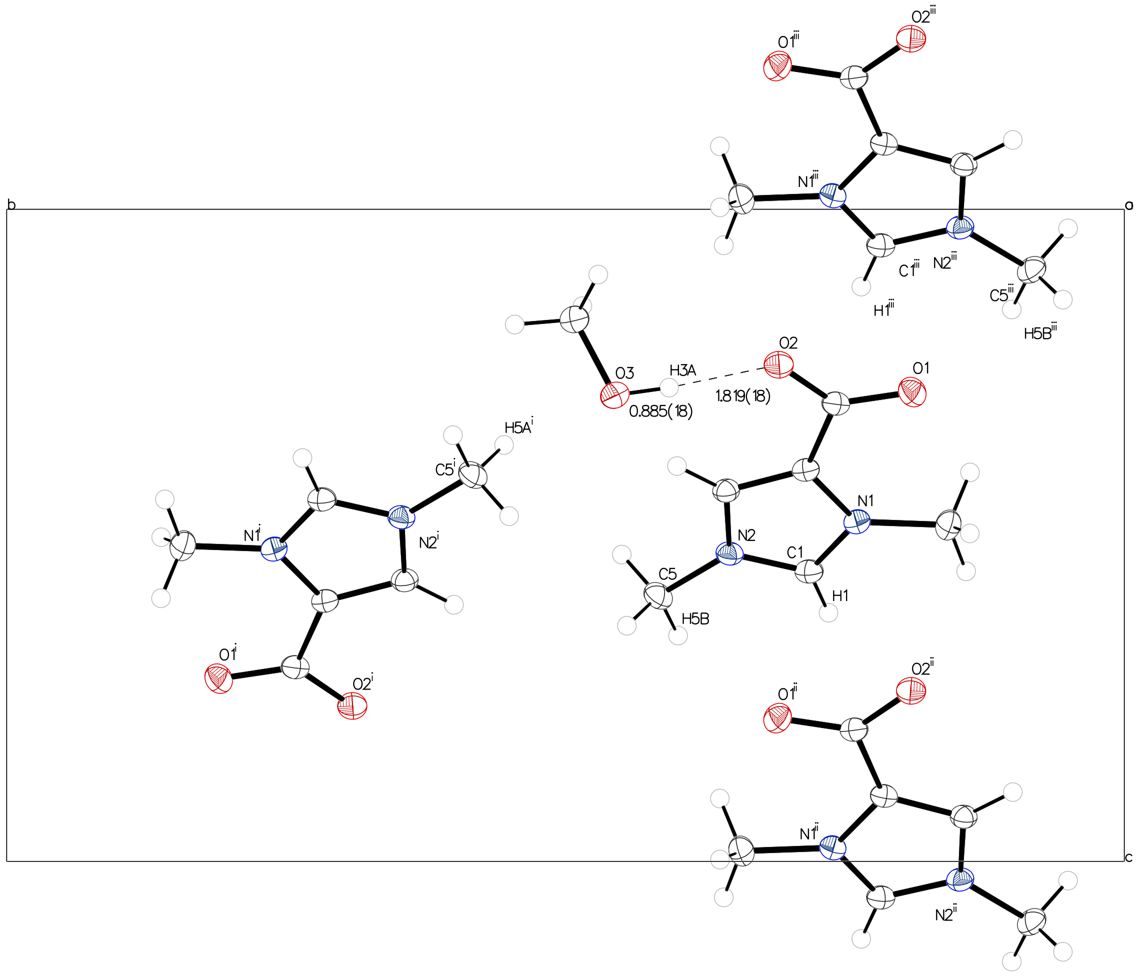


Figure S16. Packing diagram of **1**·MeOH; view along the *a* axis, distances are given in Å. Molecules were generated by the following operations: i) 2-x, 1-y, 1-z; ii) -1+x, ½-y, ½+z; iii) 1+x, ½-y, -½+z.

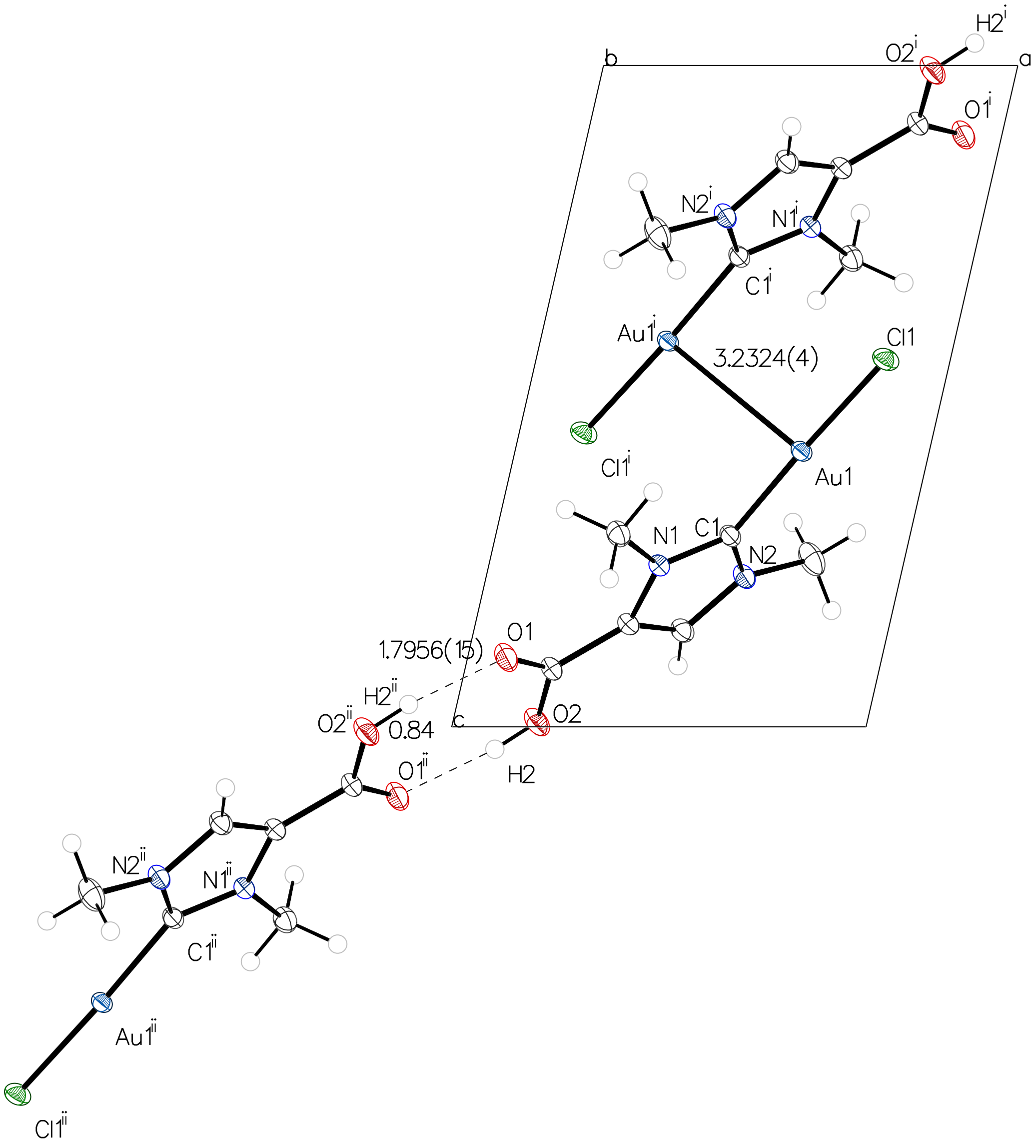


Figure S17. Packing diagram of **3** showing Au–Au contact which forms the centrosymmetric dimers and the hydrogen bonding between the carboxyl groups linking these to form chains. View along the *b* axis, distances are given in Å. Molecules were generated by the following operations: i) 1-x, 1-y, 1-z; ii) -x, 1-y, 2-z.

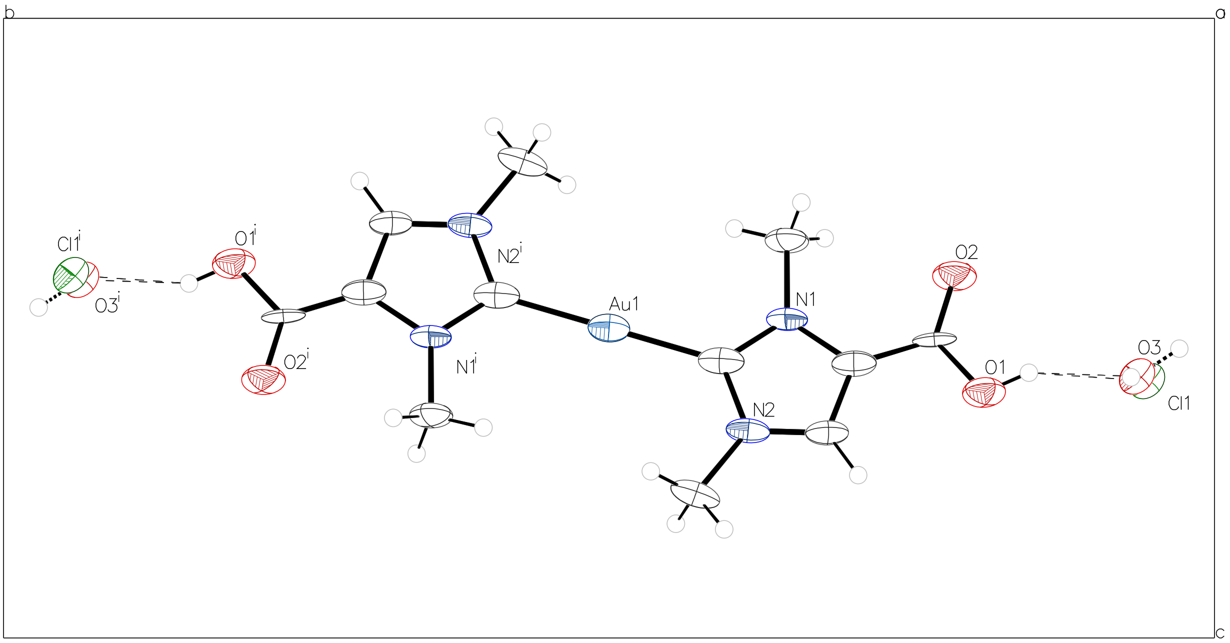


Figure S18. Packing diagram of **2**·H_2O showing the hydrogen bonds with the chloride counterions or water molecule respectively. The cloride is disorderd with the water molecule with occupancies of 50 % each. The distances, however they should be interpreted with caution because of the disorder are: O1-H1 0.839(8) Å , H1···Cl1 2.102(15) Å , H1···O3 1.87(4) Å . Additionally, the dicarbene gold complexes are stacked by weak Au–Au contacts of 3.6946(5) Å along the *a*-axis. View along the *a* axis, distances are given in Å. Molecules were generated by the following operations: i) 1-x, 1-y, 1-z.

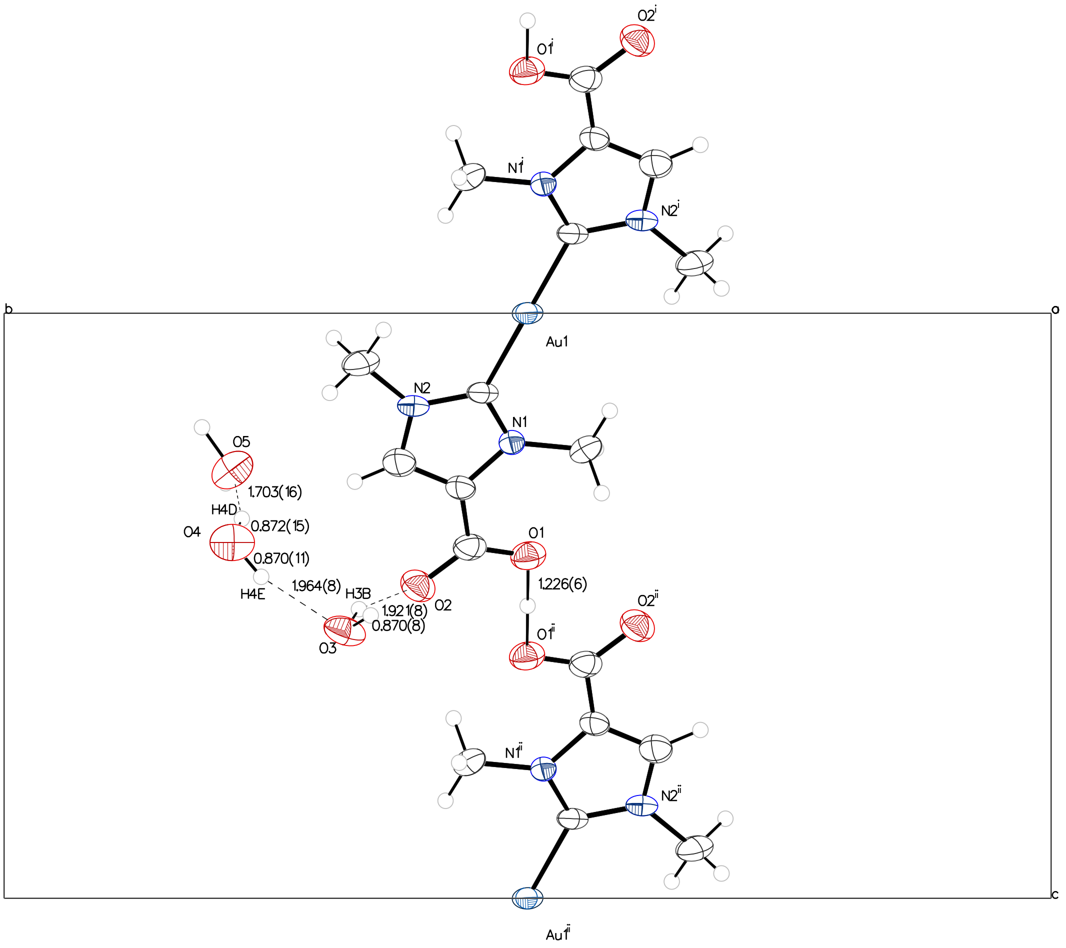


Figure S19. Packing diagram of **4**·6H_2O showing the chains along (-2 0 1) formed via the inversion centres at the gold and the hydrogen atoms at the carboxyl groups. View along the *a* axis, distances are given in Å. Molecules were generated by the following operations: i) 1-x, 1-y, -z; ii) -1-x, 1-y, 1-z.

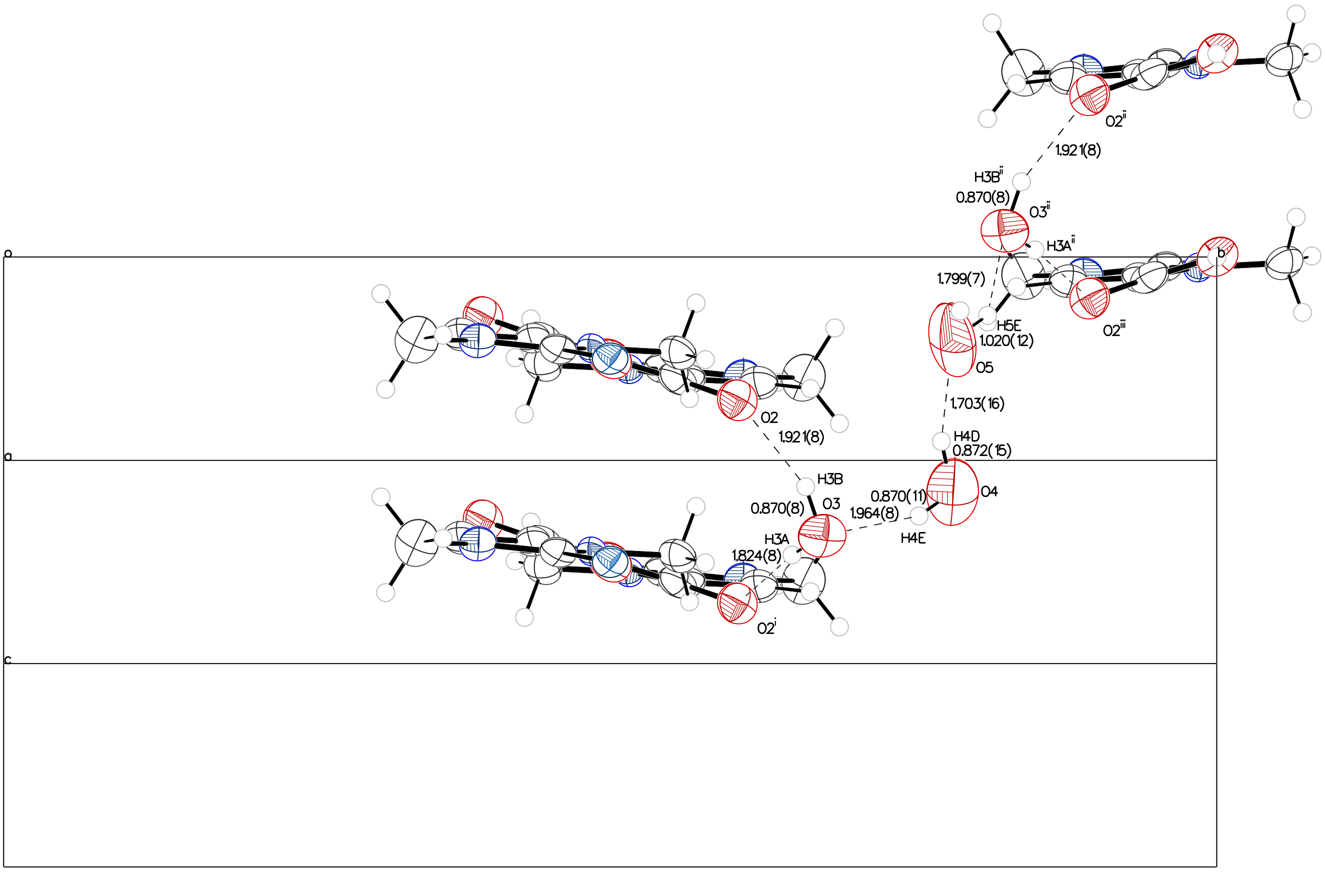


Figure S20. Packing diagram of **4**·6H_2O; view along (-2 0 1). The chains presented in Figure S19 are further linked by hydrogen bonding with the solvate water molecules. Distances are given in Å. Molecules were generated by the following operations: i) 1+x, +y, +z; ii) -½+x, 1½-y, -½+z; iii) ½+x, 1½-y, -½+z.

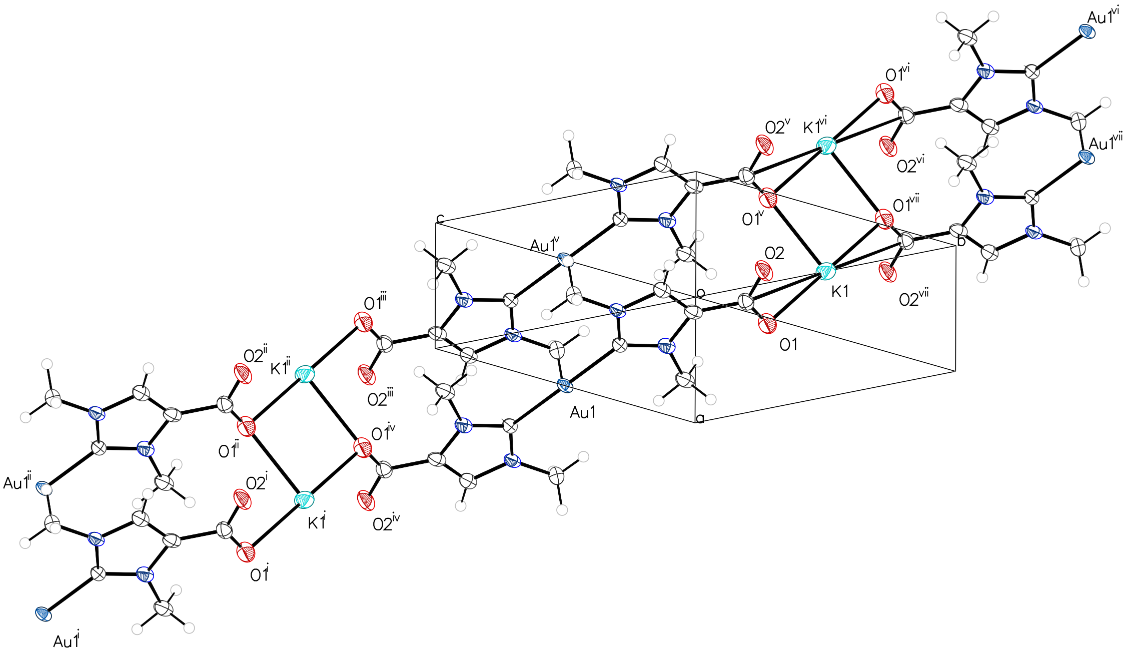


Figure S21. Packing diagram of **5**^{K}·4H_2O showing the contacts between the carboxylate groups and the potassium atoms (which suffer from disorder only the main component is shown for clatrity) resulting in a corrugated plane parallel to the *a* axis and to a diagonal of the *bc* plane. View along (1 1 1), distances are given in Å, solvate molecules are omitted for clarity. Molecules were generated by the following operations: i) 2+x, -1+y, 1+z; ii) 1+x, -1+y, 1+z; iii) 1-x, -y, 1-z; iv) 2-x, -y, 1-z; v) -1+x, +y, +z; vi) -1-x, 1-y, -z; vii) -x, 1-y, -z.

Table S1. Crystal data and structure refinement of **1**·2 H_2O.

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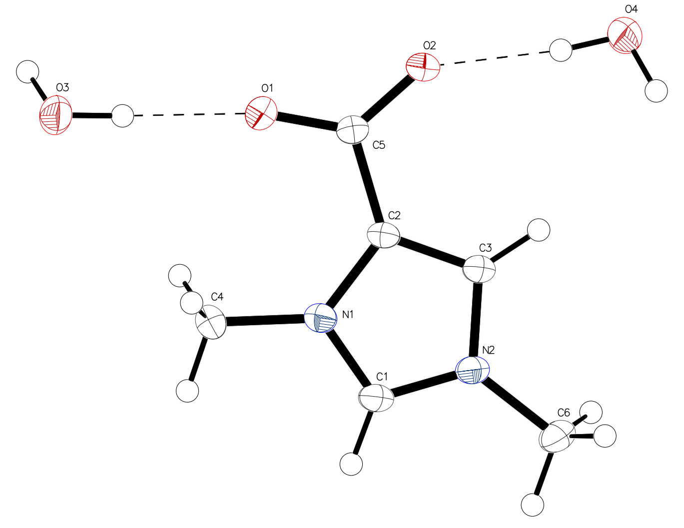
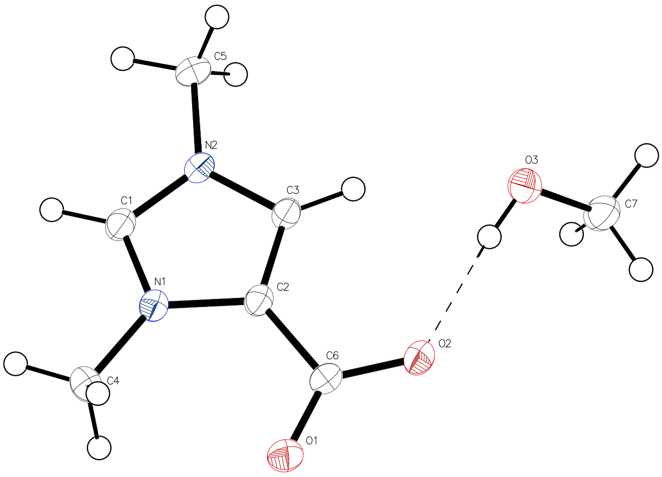
<tr><td rowspan="10"> </td><td>CCDC</td><td>2310639</td></tr>
<tr><td>Empirical formula</td><td>$C_6H_{12}N_2O_4$</td></tr>
<tr><td>Formula weight</td><td>176.18</td></tr>
<tr><td>Temperature</td><td>100(2) K</td></tr>
<tr><td>Wavelength</td><td>1.54184 Å</td></tr>
<tr><td>Crystal system</td><td>Monoclinic</td></tr>
<tr><td>Space group</td><td>$P2_1/c$</td></tr>
<tr><td colspan="2">Unit cell dimensions</td></tr>
<tr><td>a = 4.81570(10) Å</td><td>α = 90°</td></tr>
<tr><td>b = 17.5289(3) Å
c = 10.0642(2) Å</td><td>β = 98.656(2)°
γ = 90°</td></tr>
<tr><td>Volume</td><td colspan="2">839.88(3) $Å^3$</td></tr>
<tr><td>Z</td><td colspan="2">4</td></tr>
<tr><td>Density (calculated)</td><td colspan="2">1.393 Mg/m^3</td></tr>
<tr><td>Absorption coefficient</td><td colspan="2">1.005 mm^{-1}</td></tr>
<tr><td>F(000)</td><td colspan="2">376</td></tr>
<tr><td>Crystal habitus</td><td colspan="2">irregular (colourless)</td></tr>
<tr><td>Crystal size</td><td colspan="2">0.183 x 0.087 x 0.033 mm^3</td></tr>
<tr><td>Theta range for data collection</td><td colspan="2">5.112 to 77.909°</td></tr>
<tr><td>Index ranges</td><td colspan="2">$-6 \leq h \leq 6$, $-21 \leq k \leq 22$, $-12 \leq l \leq 12$</td></tr>
<tr><td>Reflections collected</td><td colspan="2">3755</td></tr>
<tr><td>Independent reflections</td><td colspan="2">3755</td></tr>
<tr><td>Completeness to θ = 67.684°</td><td colspan="2">99.7 %</td></tr>
<tr><td>Max. and min. transmission</td><td colspan="2">1.00000 and 0.47044</td></tr>
<tr><td>Data / restraints / parameters</td><td colspan="2">3755 / 0 / 128</td></tr>
<tr><td>Goodness-of-fit on F^2</td><td colspan="2">1.143</td></tr>
<tr><td>Final R indices [I > 2σ(I)]</td><td colspan="2">R1 = 0.0448, wR2 = 0.1439</td></tr>
<tr><td>R indices (all data)</td><td colspan="2">R1 = 0.0474, wR2 = 0.1475</td></tr>
<tr><td>Largest diff. peak and hole</td><td colspan="2">0.333 and -0.312 e·$Å^{-3}$</td></tr>
<tr><td>Crystallisation Details:</td><td colspan="2">from ethanol and methanol</td></tr>
</table>

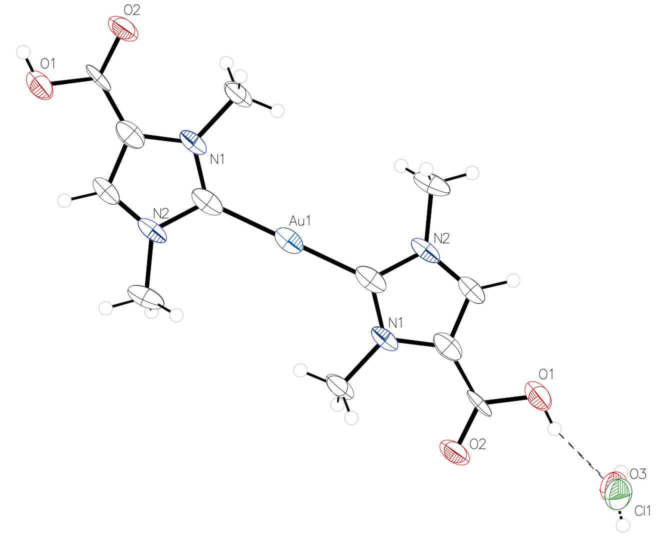
Thermal ellipsoids are presented at the 50 % level of probability. Bond distances and bond angles are reported in Å or degree (°), respectively. N2–C1 1.3352(16), N1–C1 1.3309(17), O2–C5 1.2550(15), O1–C5 1.2493(16), N1–C1–N2 108.67(11), N1–C2–C5 126.56(11), C1–N1–C2 108.74(11), C1–N1–C4 122.89(11), O1–C5–O2 126.78(12).

Table S2. Crystal data and structure refinement of **1**·MeOH.

<table>
<tr><td rowspan="11">
</td><td>CCDC</td><td>2310640</td></tr>
<tr><td>Empirical formula</td><td>$C_7H_{12}N_2O_3$</td></tr>
<tr><td>Formula weight</td><td>172.19</td></tr>
<tr><td>Temperature</td><td>100(2) K</td></tr>
<tr><td>Wavelength</td><td>1.54184 Å</td></tr>
<tr><td>Crystal system</td><td>Monoclinic</td></tr>
<tr><td>Space group</td><td>$P2_1/c$</td></tr>
<tr><td colspan="2">Unit cell dimensions</td></tr>
<tr><td>a = 4.43360(10) Å</td><td>α = 90°</td></tr>
<tr><td>b = 17.9129(2) Å</td><td>β = 95.263(2)°</td></tr>
<tr><td>c = 10.4981(2) Å</td><td>γ = 90°</td></tr>
<tr><td>Volume</td><td colspan="2">830.23(3) Å^3</td></tr>
<tr><td>Z</td><td colspan="2">4</td></tr>
<tr><td>Density (calculated)</td><td colspan="2">1.378 Mg/m^3</td></tr>
<tr><td>Absorption coefficient</td><td colspan="2">0.913 mm^{-1}</td></tr>
<tr><td>F(000)</td><td colspan="2">368</td></tr>
<tr><td>Crystal habitus</td><td colspan="2">block (colourless)</td></tr>
<tr><td>Crystal size</td><td colspan="2">0.707 x 0.304 x 0.175 mm^3</td></tr>
<tr><td>Theta range for data collection</td><td colspan="2">4.898 to 77.597°</td></tr>
<tr><td>Index ranges</td><td colspan="2">$-5 \leq h \leq 5$, $-22 \leq k \leq 22$, $-13 \leq l \leq 13$</td></tr>
<tr><td>Reflections collected</td><td colspan="2">17690</td></tr>
<tr><td>Independent reflections</td><td colspan="2">1745 [R(int) = 0.0358]</td></tr>
<tr><td>Completeness to θ = 67.684°</td><td colspan="2">99.9 %</td></tr>
<tr><td>Max. and min. transmission</td><td colspan="2">1.000 and 0.207</td></tr>
<tr><td>Data / restraints / parameters</td><td colspan="2">1745 / 0 / 116</td></tr>
<tr><td>Goodness-of-fit on F^2</td><td colspan="2">1.067</td></tr>
<tr><td>Final R indices [I > 2σ(I)]</td><td colspan="2">R1 = 0.0321, wR2 = 0.0878</td></tr>
<tr><td>R indices (all data)</td><td colspan="2">R1 = 0.0330, wR2 = 0.0885</td></tr>
<tr><td>Largest diff. peak and hole</td><td colspan="2">0.247 and -0.220 e·Å^{-3}</td></tr>
<tr><td>Crystallisation Details:</td><td colspan="2">from methanol</td></tr>
</table>

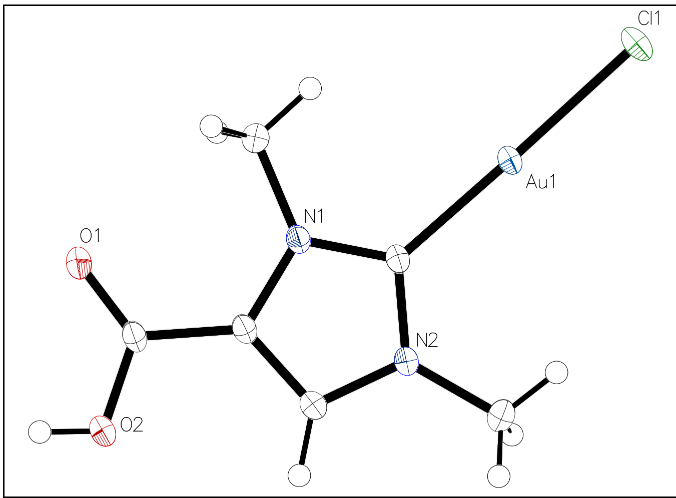
Thermal ellipsoids are presented at the 50 % level of probability. Bond distances and bond angles are reported in Å or degree (°), respectively. N2–C1 1.3284(14), N1–C1 1.3313 (13), O2–C6 1.2632(13), O1–C6 1.2437(13), N1–C1–N2 108.75(9), N1–C2–C6 125.42(8), C1–N1–C2 108.75(9), C1–N1–C4 122.73(8), O1–C5–O2 126.92(18).

Table S3. Crystal data and structure refinement of **2**·H_2O.

<table>
<tr><td rowspan="11"> </td><td>CCDC</td><td>2310641</td></tr>
<tr><td>Empirical formula</td><td>$C_{12}H_{18}AuClN_4O_5$</td></tr>
<tr><td>Formula weight</td><td>530.72</td></tr>
<tr><td>Temperature</td><td>100(2) K</td></tr>
<tr><td>Wavelength</td><td>1.54184 Å</td></tr>
<tr><td>Crystal system</td><td>Monoclinic</td></tr>
<tr><td>Space group</td><td>$P2_1/c$</td></tr>
<tr><td colspan="2">Unit cell dimensions</td></tr>
<tr><td>a = 3.6946(5) Å</td><td>α = 90°</td></tr>
<tr><td>b = 20.679(2) Å</td><td>β = 99.603(11)°</td></tr>
<tr><td>c = 10.7340(11) Å</td><td>γ = 90°</td></tr>
<tr><td>Volume</td><td colspan="2">808.59(16) Å^3</td></tr>
<tr><td>Z</td><td colspan="2">2</td></tr>
<tr><td>Density (calculated)</td><td colspan="2">2.180 Mg/m^3</td></tr>
<tr><td>Absorption coefficient</td><td colspan="2">18.908 mm^{-1}</td></tr>
<tr><td>F(000)</td><td colspan="2">508</td></tr>
<tr><td>Crystal habitus</td><td colspan="2">needle (colourless)</td></tr>
<tr><td>Crystal size</td><td colspan="2">0.043 x 0.014 x 0.011 mm^3</td></tr>
<tr><td>Theta range for data collection</td><td colspan="2">4.276 to 77.572°</td></tr>
<tr><td>Index ranges</td><td colspan="2">$-4 \leq h \leq 4$, $-26 \leq k \leq 25$, $-13 \leq l \leq 13$</td></tr>
<tr><td>Reflections collected</td><td colspan="2">20080</td></tr>
<tr><td>Independent reflections</td><td colspan="2">1721 [R(int) = 0.0905]</td></tr>
<tr><td>Completeness to θ = 67.684°</td><td colspan="2">100.0 %</td></tr>
<tr><td>Max. and min. transmission</td><td colspan="2">1.00000 and 0.59375</td></tr>
<tr><td>Data / restraints / parameters</td><td colspan="2">1721 / 0 / 115</td></tr>
<tr><td>Goodness-of-fit on F^2</td><td colspan="2">1.246</td></tr>
<tr><td>Final R indices [I > 2σ(I)]</td><td colspan="2">R1 = 0.0553, wR2 = 0.0962</td></tr>
<tr><td>R indices (all data)</td><td colspan="2">R1 = 0.0735, wR2 = 0.1013</td></tr>
<tr><td>Largest diff. peak and hole</td><td colspan="2">1.628 and -0.968 e·Å^{-3}</td></tr>
<tr><td>Crystallisation Details:</td><td colspan="2">from THF and methanol</td></tr>
</table>

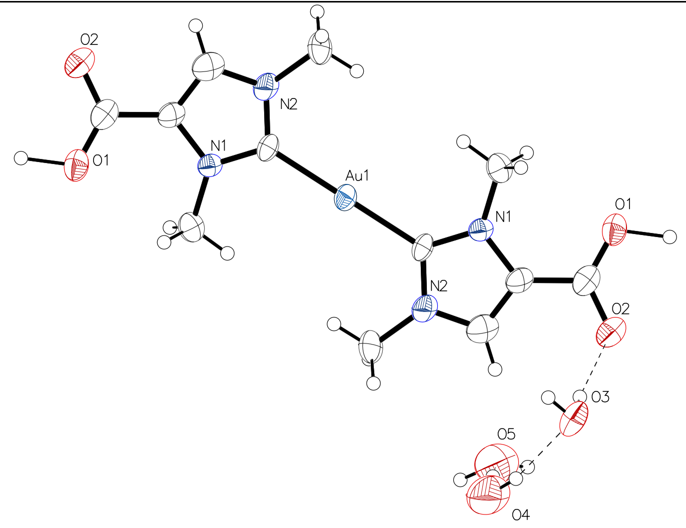
Thermal ellipsoids are presented at the 50 % level of probability. Bond distances and bond angles are reported in Å or degree (°), respectively. C1-Au1 2.010(10), N2−C1 1.375(11), N1−C1 1.356(12), O2−C5 1.221(10), O1−C5 1.316(10), N2−C1−N1 104.5(8), N1−C1−Au1 128.6(6), O2−C5−O1 123.7(9), O1−C5−C2 112.1(7), O2−C5−C2 124.1(8), N2−C1−Au1 126.8(7), C3−C2−N1 105.9(8), C3−C2−C5 127.7(8).

Table S4. Crystal data and structure refinement of **3**.

	CCDC	2310642
	Empirical formula	$C_6H_8AuClN_2O_2$
	Formula weight	372.56
	Temperature	100(2) K
	Wavelength	0.71073 Å
	Crystal system	Monoclinic
	Space group	$P2_1/n$
	Unit cell dimensions	
	a = 6.76910(10) Å	α = 90°
	b = 12.2956(2) Å	β = 102.935(2)°
	c = 11.0786(2) Å	γ = 90°
Volume	898.68(3) $Å^3$	
Z	4	
Density (calculated)	2.754 Mg/m^3	
Absorption coefficient	16.627 mm^{-1}	
F(000)	680	
Crystal habitus	block (colourless)	
Crystal size	0.264 x 0.119 x 0.099 mm^3	
Theta range for data collection	3.238 to 58.805°	
Index ranges	$-15 \leq h \leq 16$, $-29 \leq k \leq 29$, $-26 \leq l \leq 26$	
Reflections collected	127069	
Independent reflections	13013 [R(int) = 0.0576]	
Completeness to θ = 25.242°	99.9 %	
Max. and min. transmission	0.638 and 0.055	
Data / restraints / parameters	13013 / 0 / 112	
Goodness-of-fit on F^2	1.113	
Final R indices [I > 2σ(I)]	R1 = 0.0254, wR2 = 0.0576	
R indices (all data)	R1 = 0.0335, wR2 = 0.0596	
Largest diff. peak and hole	4.381 and -3.580 e·$Å^{-3}$	
Crystallisation Details:	from methanol	

Thermal ellipsoids are presented at the 50 % level of probability. Bond distances and bond angles are reported in Å or degree (°), respectively. C1-Au1 1.9849 (12), Au1-Cl1 2.2908 (3), N1−C1 1.3460(16), N2−C1 1.3639(17), O2−C4 1.3247(18), O1−C4 1.2260(18), O2−H2 0.84, N1−C1−N2 105.95(11), N1−C1−Au1 127.47(9), C1−Au1−Cl 176.50(4), O1−C4−O2 124.14(13), O1−C4−C2 123.17(13), O2−C4−C2 112.69(12), N2−C1−Au1 126.59(9), C3−C2−N1 107.00(11), C3−C2−C4 127.99(12).

Table S5. Crystal data and structure refinement of **4**·6H_2O.

<table>
<tr><td rowspan="11"> </td><td>CCDC</td><td>2310643</td></tr>
<tr><td>Empirical formula</td><td>$C_{12}H_{27}AuN_4O_{10}$</td></tr>
<tr><td>Formula weight</td><td>584.34</td></tr>
<tr><td>Temperature</td><td>100(2) K</td></tr>
<tr><td>Wavelength</td><td>1.54184 Å</td></tr>
<tr><td>Crystal system</td><td>Monoclinic</td></tr>
<tr><td>Space group</td><td>$P2_1/n$</td></tr>
<tr><td colspan="2">Unit cell dimensions</td></tr>
<tr><td>a = 4.3054(4) Å</td><td>α = 90°</td></tr>
<tr><td>b = 20.233(3) Å</td><td>β = 91.190(9)°</td></tr>
<tr><td>c = 11.3141(11) Å</td><td>γ = 90°</td></tr>
<tr><td>Volume</td><td colspan="2">985.4(2) Å^3</td></tr>
<tr><td>Z</td><td colspan="2">2</td></tr>
<tr><td>Density (calculated)</td><td colspan="2">1.969 Mg/m^3</td></tr>
<tr><td>Absorption coefficient</td><td colspan="2">14.559 mm^{-1}</td></tr>
<tr><td>F(000)</td><td colspan="2">572</td></tr>
<tr><td>Crystal habitus</td><td colspan="2">needle (colourless)</td></tr>
<tr><td>Crystal size</td><td colspan="2">0.160 x 0.020 x 0.010 mm^3</td></tr>
<tr><td>Theta range for data collection</td><td colspan="2">4.370 to 75.892°</td></tr>
<tr><td>Index ranges</td><td colspan="2">$-5 \leq h \leq 4$, $-25 \leq k \leq 25$, $-14 \leq l \leq 14$</td></tr>
<tr><td>Reflections collected</td><td colspan="2">14935</td></tr>
<tr><td>Independent reflections</td><td colspan="2">1958 [R(int) = 0.0664]</td></tr>
<tr><td>Completeness to θ = 67.684°</td><td colspan="2">99.3 %</td></tr>
<tr><td>Max. and min. transmission</td><td colspan="2">1.00000 and 0.43715</td></tr>
<tr><td>Data / restraints / parameters</td><td colspan="2">1958 / 0 / 136</td></tr>
<tr><td>Goodness-of-fit on F^2</td><td colspan="2">1.074</td></tr>
<tr><td>Final R indices [I > 2σ(I)]</td><td colspan="2">R1 = 0.0432, wR2 = 0.0975</td></tr>
<tr><td>R indices (all data)</td><td colspan="2">R1 = 0.0705, wR2 = 0.1073</td></tr>
<tr><td>Largest diff. peak and hole</td><td colspan="2">2.224 and -0.923 e·Å^{-3}</td></tr>
<tr><td>Crystallisation Details:</td><td colspan="2">from methanol and water</td></tr>
</table>

Thermal ellipsoids are presented at the 50 % level of probability. Bond distances and bond angles are reported in Å or degree (°), respectively. C1-Au1 2.027(8), N2–C1 1.362(12), N1–C1 1.337(11), O2–C6 1.257(12), O1–C6 1.277(12), N1–C1–N2 105.6(7), N1–C1–Au1 129.5(7), O2–C6–O1 125.5(9), O1–C6–C2 118.5(8), O2–C6–C2 115.9(10), C3–C2–N1 106.0(8), C3–C2–C6 126.2(10).

Table S6. Crystal data and structure refinement of **5**$^{\mathbf{K}}$·2H$_2$O·MeOH.

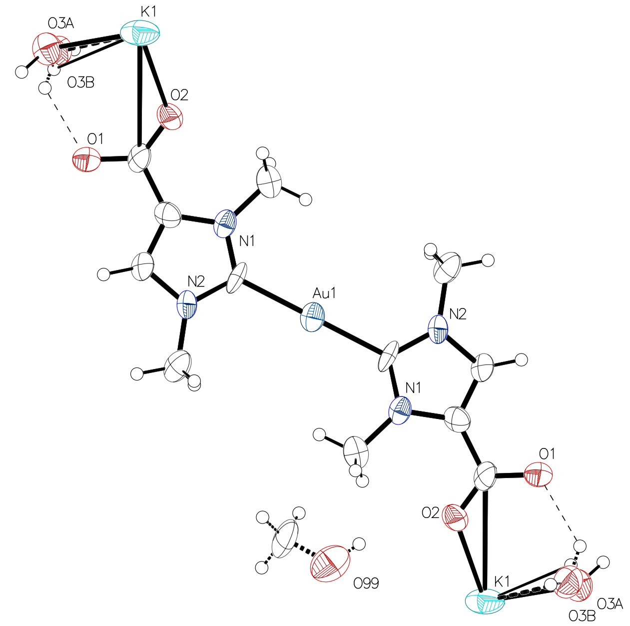
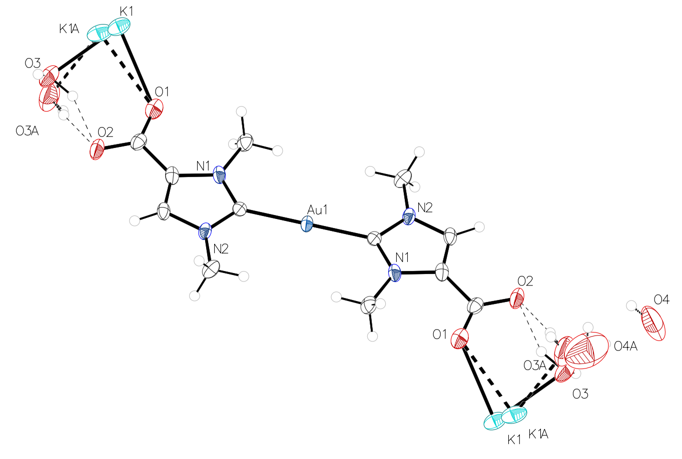
	CCDC	2310645
	Empirical formula	$C_{13}H_{22}AuKN_4O_7$
	Formula weight	582.41
	Temperature	100(2) K
	Wavelength	1.54184 Å
	Crystal system	Triclinic
	Space group	$P\bar{1}$
	Unit cell dimensions	
	a = 3.8030(2) Å	α = 79.722(7)°
	b = 10.9370(12) Å	β = 82.574(5)°
	c = 11.4861(8) Å	γ = 81.366(7)°
Volume	462.17(7) Å^3	
Z	1	
Density (calculated)	2.093 Mg/m^3	
Absorption coefficient	17.375 mm^{-1}	
F(000)	282	
Crystal habitus	irregular (colourless)	
Crystal size	0.059 x 0.024 x 0.013 mm^3	
Theta range for data collection	4.143 to 76.221°	
Index ranges	$-4 \le h \le 4$, $-13 \le k \le 13$, $-14 \le l \le 11$	
Reflections collected	5680	
Independent reflections	1792 [R(int) = 0.0884]	
Completeness to θ = 67.684°	97.5 %	
Max. and min. transmission	0.874 and 0.554	
Data / restraints / parameters	1792 / 0 / 146	
Goodness-of-fit on F^2	1.209	
Final R indices [I > 2σ(I)]	R1 = 0.1068, wR2 = 0.2720	
R indices (all data)	R1 = 0.1125, wR2 = 0.2801	
Largest diff. peak and hole	8.532 and -5.490 e·Å^{-3}	
Crystallisation Details:	from methanol	

Table S7. Crystal data and structure refinement of **5**$^{\mathrm{K}}$$\cdot 4H_2O$.

	CCDC	2310644
	Empirical formula	$C_{12}H_{22}AuKN_4O_8$
	Formula weight	586.40
	Temperature	100(2) K
	Wavelength	0.71073 Å
	Crystal system	Triclinic
	Space group	$P\bar{1}$
	Unit cell dimensions	
	a = 3.78331(13) Å	α = 79.885(5)°
	b = 11.0885(5) Å	β = 82.696(4)°
	c = 11.4646(7) Å	γ = 80.471(3)°
Volume	464.56(4) Å^3	
Z	1	
Density (calculated)	2.096 Mg/m^3	
Absorption coefficient	8.188 mm^{-1}	
F(000)	284	
Crystal habitus	irregular (colourless)	
Crystal size	0.140 x 0.040 x 0.020 mm^3	
Theta range for data collection	2.401 to 32.576°	
Index ranges	$-5 \le h \le 5$, $-15 \le k \le 15$, $-16 \le l \le 16$	
Reflections collected	4572	
Independent reflections	4572	
Completeness to θ = 25.242°	99.8 %	
Max. and min. transmission	1.000 and 0.414	
Data / restraints / parameters	4572 / 42 / 163	
Goodness-of-fit on F^2	1.155	
Final R indices [I > 2σ(I)]	R1 = 0.0411, wR2 = 0.1013	
R indices (all data)	R1 = 0.0430, wR2 = 0.1022	
Largest diff. peak and hole	2.007 and -2.056 e·Å^{-3}	
Crystallisation Details:	from water and ethanol	

Thermal ellipsoids are presented at the 50 % level of probability. Bond distances and bond angles are reported in Å or degree (°), respectively. C1-Au1 2.021(7), N2–C1 1.355(9), N1–C1 1.353(9), N1–C2 1.394(9), O2–C6 1.261(9), O1–C6 1.252(9), O1–C6–O2 126.4(7), O1–C6–C2 117.6(6), N1–C1–N2 105.0(6), N1–C1–Au1 127.9(5), N2–C1–Au1 127.0(5), C3–C2–N1 106.1(6), C3–C2–C6 128.4(7).

Biological data

Antibacterial Assays

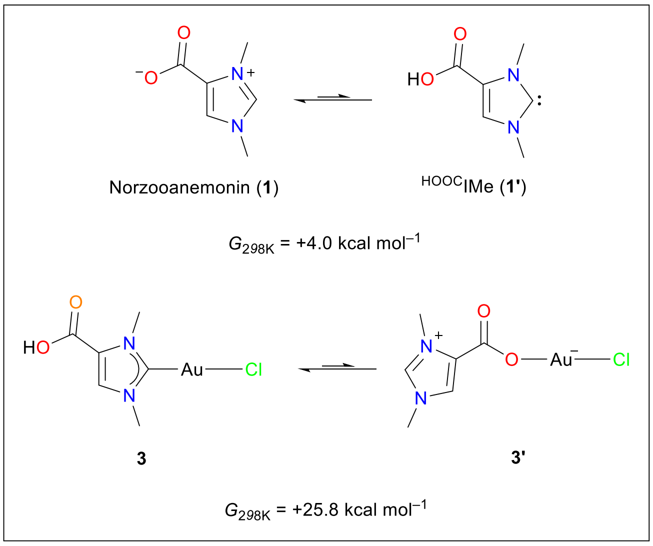
Overnight cultures of the bacteria were grown aerobically at 37 °C in Müller Hinton broth with added 1% glucose and pH 7.2 for Gram-negative strains, or with Trypticase soy yeast extract medium (TSY – 30 g/l trypticase soy broth, 3 g/L yeast extract, pH 7.2) for Gram-positive strains. The cultures were adjusted to an OD600 nm of 0.001, which resulted in a final start OD600 nm of 0.0005 in the test. 25 µL of test culture was added to 25 µL of a serial dilution of the test compounds in the appropriate medium for the different strains in accordance with standardized procedures in 384 well plates. For screening purposes, the residual absorbance in % was tested at compound concentrations of 0.5 , 5 and 50 µM. For selected compounds, concentration-dependent growth inhibition curves were recorded from stock solutions in DMSO at final concentrations of 100, 50, 25, 12.5, 6,25, 3.125, 1.56, 0.78, 0.39, 0.2 µM. As positive control compounds, Linezolid (both MRSA strains) Ciprofloxacin (*E. faecium, E. coli*), and Amikacin (*P. aeruginosa*) were applied. The highest DMSO concentration in the assay was 1%, which had no apparent effect on the growth of the bacteria. After an incubation time of 18 h at 37 °C under moist conditions, the optical density at 600 nm was measured with a Fusion Universal Microplate Analyser (Perkin–Elmer, Waltham, USA). The lowest concentration that completely suppressed growth defined the MIC values. The MIC values were determined by curve fitting with Sigma Plot. The following bacterial strains were used: Gram-negative: *Escherichia coli* (DSM 1116), *A. baumannii* (DSM30007), *K. pneumoniae* (DSM111678) and *Pseudomonas aeruginosa* PA7 (DSM 24068). Gram-positive: *E. faecium* (DSM20477) and *Staphylococcus aureus* MRSA (DSM 11822).

Inhibition of bacterial TrxR (E.coli) and Antiproliferative assay in tumorigenic and non-tumorgenic cells

The TrxR (E.coli) inhibition assay and antiproliferative effects were performed according to a previously published procedure.[8]

Theoretical Calculations

All calculations were performed using the density functional method B97-D (S. Grimme) as implemented in the Gaussian16 program.[9] For all main group elements (C, H, N, O and Cl) the Pople-type all-electron triple-ζ basis set augmented with one set of polarization functions 6-311G(d,p) was used, along with a fully relativistic effective core pseudopotential – Stuttgart-Koeln (ECP60MDF) – for the heavy element gold.[10] Harmonic vibrational frequencies are calculated to characterise the respective minima (without imaginary frequency).



Scheme 1. The energy difference between the tautomers

Table S8. Energies for all optimized structures

Compound		$E_{0K}{}^{a}$ / [Ha]	$E_{298K}{}^{b}$ / [Ha]	$H_{298K}{}^{b}$ / [Ha]	$G_{298K}{}^{b}$ / [Ha]
Norzooanemonin	**1**	-493.043324	-493.033128	-493.032183	-493.079855
^{HOOC}IMe (NHC)	**1'**	-493.037789	-493.027815	-493.026871	-493.073415
Δ*E* [kcal mol^{-1}]	**(1' – 1)**	**3.5**	**3.3**	**3.3**	**4.0**
(^{HOOC}IMe)-AuCl	**3**	-1089.387455	-1089.373759	-1089.372814	-1089.430996
(Norzooanemonin)-AuCl	**3'**	-1089.344053	-1089.329932	-1089.328988	-1089.389876
Δ*E* [kcal mol^{-1}]	**(3' – 3)**	**27.2**	**27.5**	**27.5**	**25.8**

[a] DFT energy incl. ZPE.
[b] standard conditions T = 298.15 K and p = 1 atm.

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