**Dalton Transactions**

Electronic Supplementary Information associated with the paper

# Synthesis, characterization, biological activity, DNA and BSA binding study: novel copper(II) complexes with 2-hydroxy-4-aryl-4-oxo-2-butenoate

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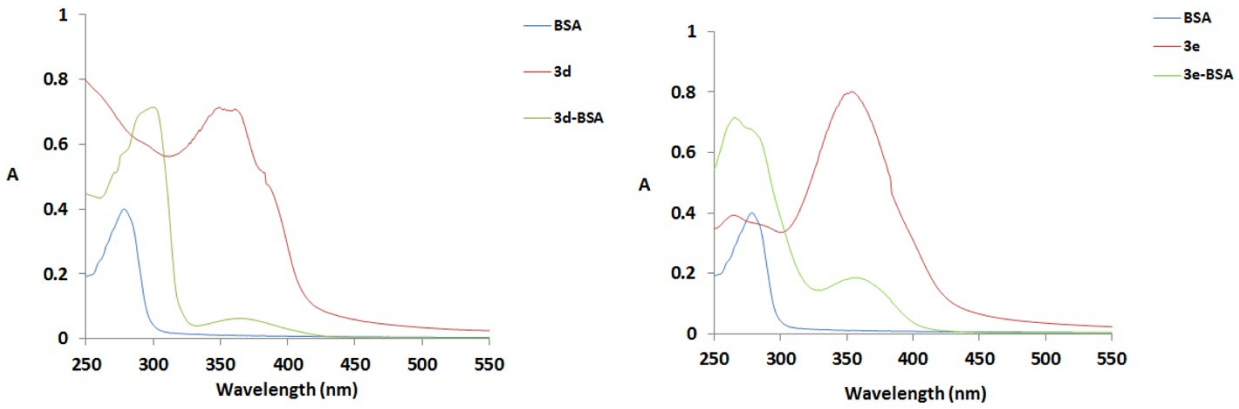



Fig. S1 UV-Vis spectrum of BSA, **3d**, **3e**, **3d**-BSA and **3e**-BSA (with 5h incubation time).

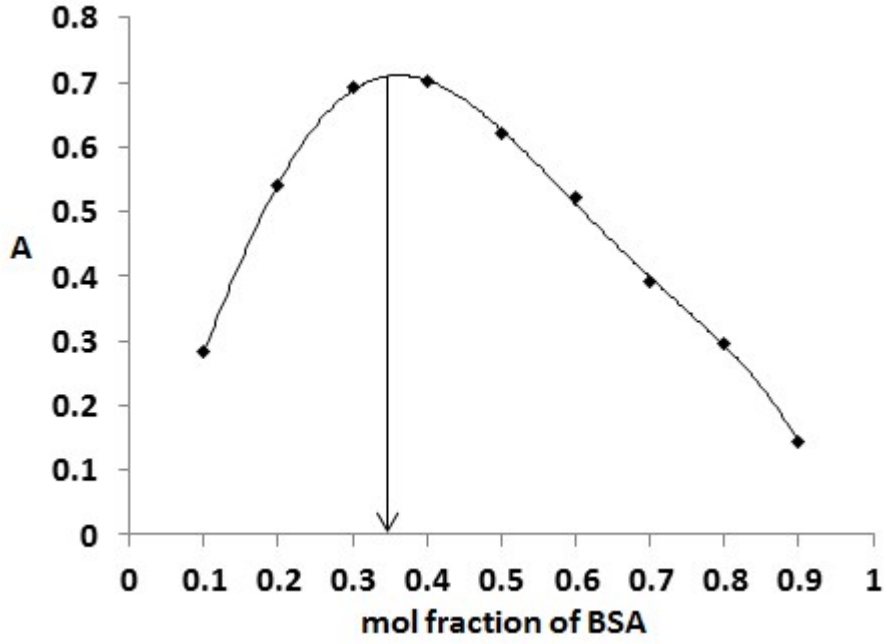



Fig. S2 Job plot for interaction between **3d** and BSA in 10 mM PBS bu□er at pH = 7.4.

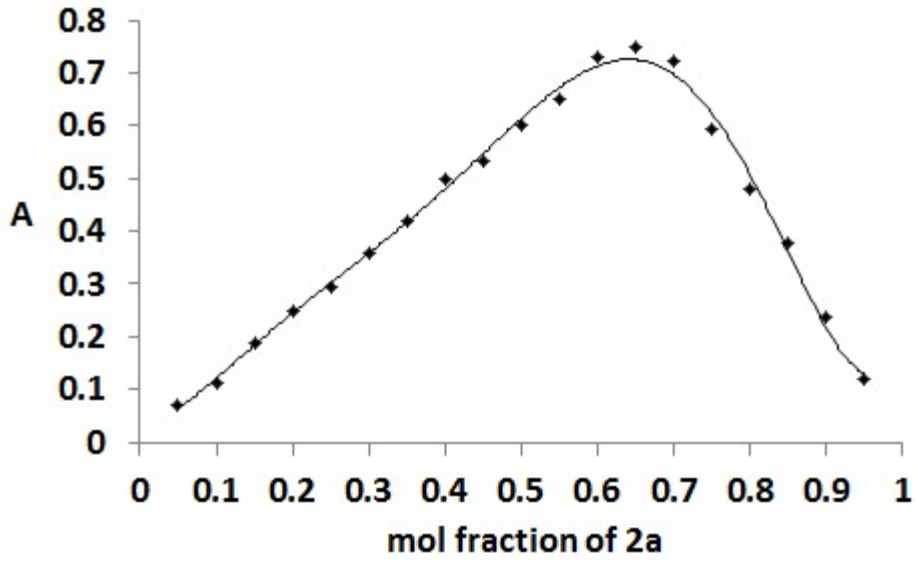
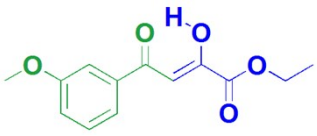



Fig. S3 Job plot for $Cu^{2+}$ -2a system obtained by spectrophotometric analysis.

ethyl 2-hydroxy-4-(3'-metoxyphenyl)-4-oxo-2-butenoate (**2a**)



$^{1}$H NMR ($CDCl_3$, 200 MHz) δ (ppm) : 1.38-1.45 (t, *J* = 7.0 Hz, 3H, $CH_3$), 3,88 (s, 3H, $OCH_3$) 4.35-4.46 (q, *J* = 7.1 Hz, 2H, $CH_2$), 7.06 (s, 1H, CH=CO), 7.12-7.18 (m, 1H, $CH_{Ar}$), 7.37-7.59 (m, 3H, $CH_{Ar}$), and 15.28 (br. s., 1H, OH). $^{13}$C NMR ($CDCl_3$, 50 MHz) δ (ppm): 14.0, 55.5, 62.5, 98.2, 112.3, 120.1, 120.4, 129.8, 136.4, 160.0, 162.2, 169.4 and 190.7

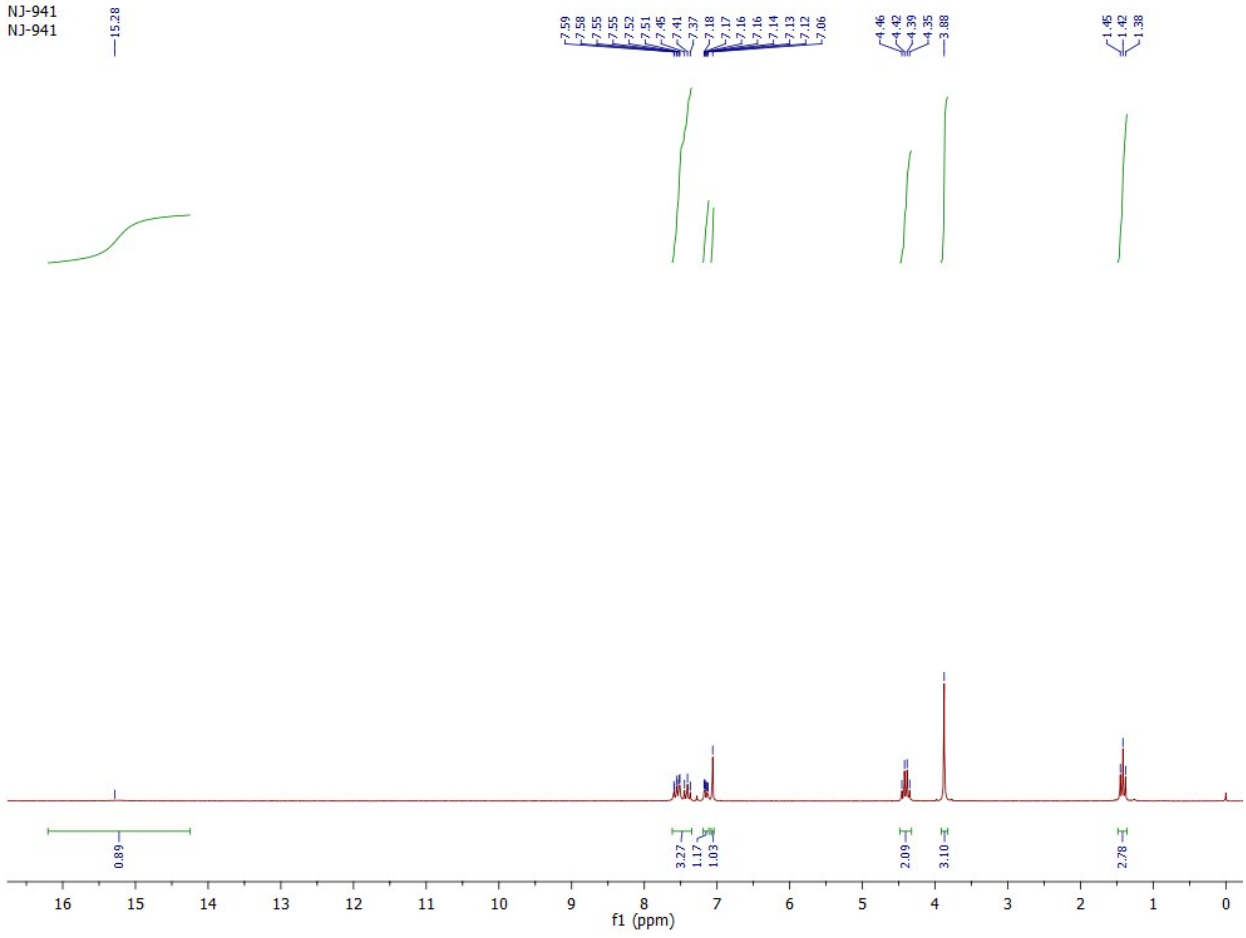



Fig. S4 $^{1}$H NMR spectrum of **2a**

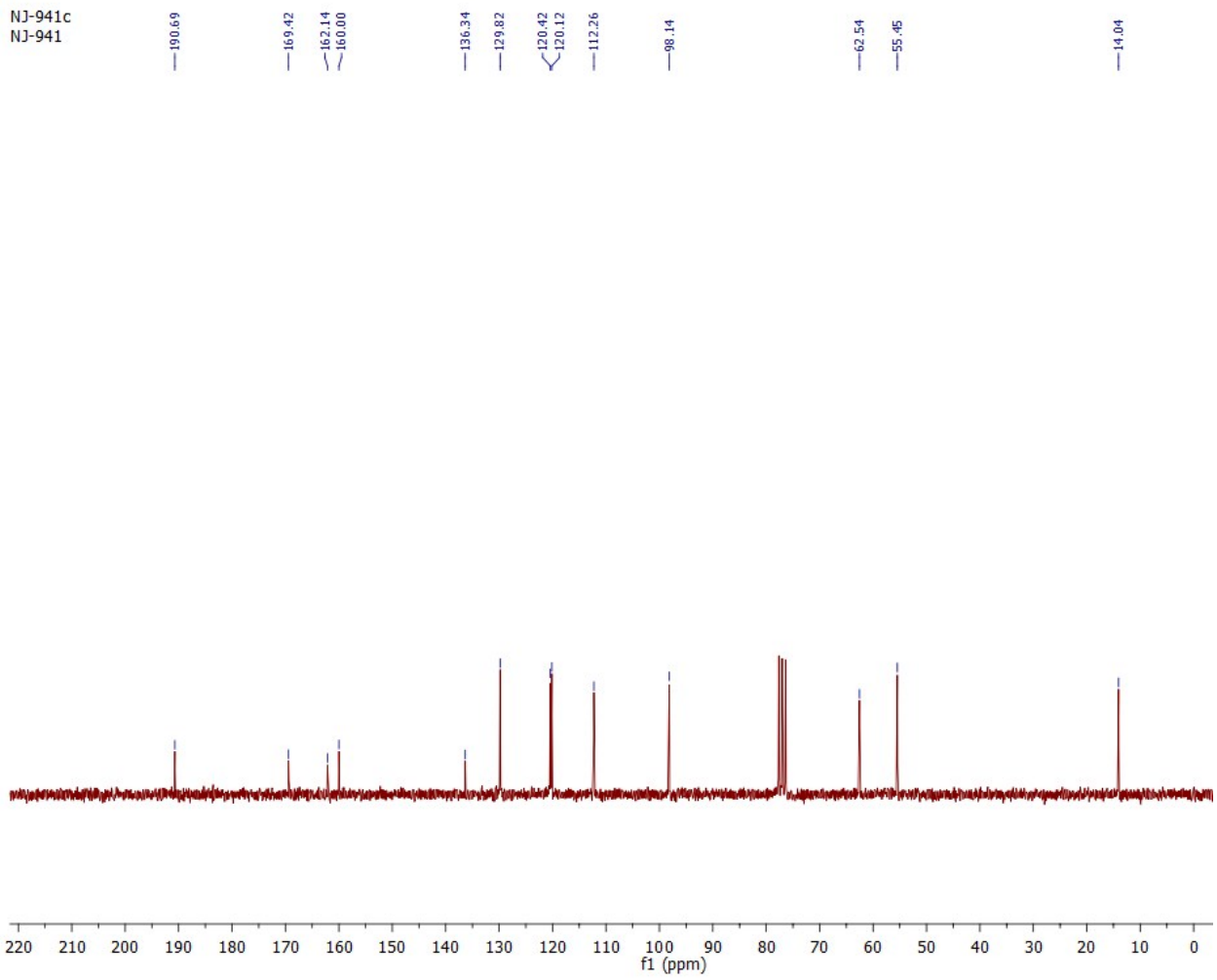
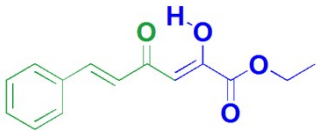



Fig. S5 $^{13}$C NMR spectrum of **2a**

ethyl 2-hydroxy-4-[(*E*)-2-phenylvinyl)]-4-oxo-2-butenoate (**2b**)



$^{1}$H NMR ($CDCl_3$, 200 MHz) δ (ppm) : 1.37-1.44 (t, $J$ = 7.0 Hz, 3H, $CH_3$), 4.32-4.43 (q, $J$ = 7.1 Hz, 2H, $CH_2$), 6.55 (s, 1H, CH=CO), 6.62-6.70 (d, $J_{vicinal,trans}$ = 16.0 Hz, 1H, CH=CH), 7.40-7.43 (m, 3H, $CH_{Ar}$), 7.55-7.60 (m, 2H, $CH_{Ar}$), 7.70-7.78 (d, $J_{vicinal,trans}$ = 16.0 Hz, 1H, CH=CH) and 14.77 (br. s., 1H, OH). $^{13}$C NMR ($CDCl_3$, 50 MHz) δ (ppm) :14.0, 62.5, 100.6, 123.0, 128.4, 129.0, 130.8, 134.3, 143.2, 162.0, 174.3 and 184.9.

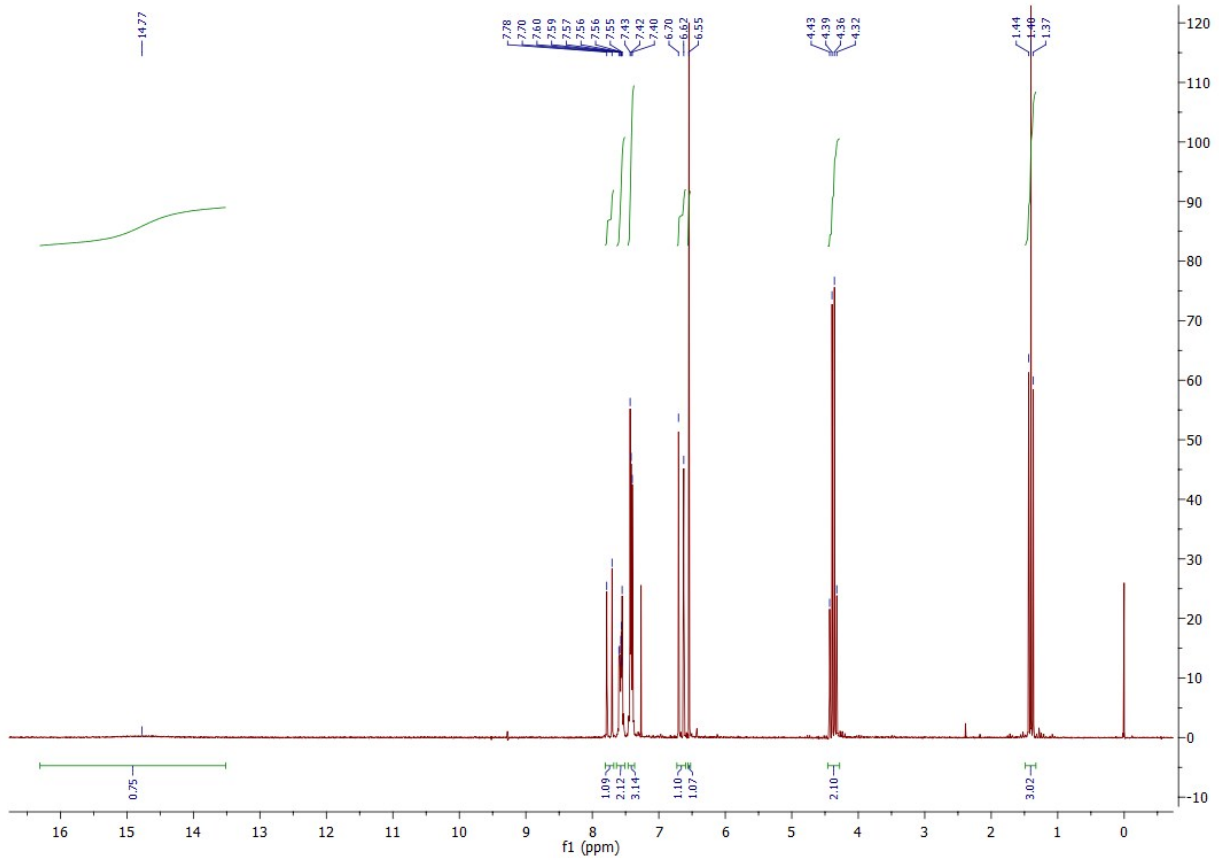



Fig. S6 $^{1}$H NMR spectrum of **2b**

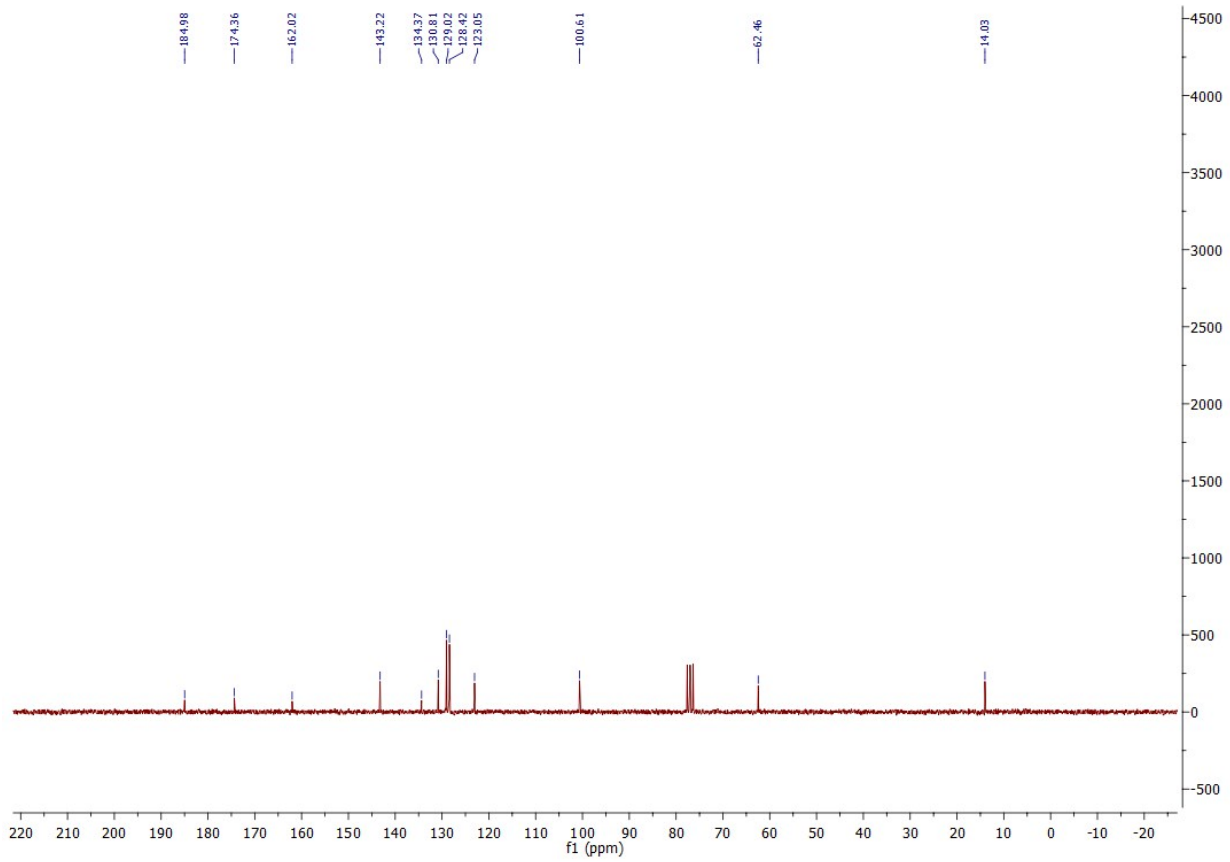
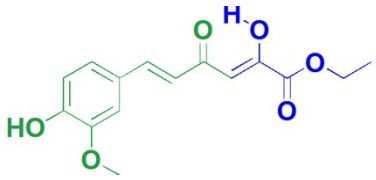



Fig. S7 $^{13}$C NMR spectrum of **2b**

ethyl 2-hydroxy-4-[(*E*)-2-(4'-hydroxy-3'-methoxyphenyl)vinyl)]-4-oxo-2-butenoate (**2c**)




$^{1}$H NMR ($CDCl_3$, 200 MHz) δ (ppm) : 1.36-1.43 (t, $J$ = 7.0 Hz, 3H, $CH_3$), 3.95 (s, 3H, $OCH_3$), 4.32-4.42 (q, $J$ = 7.1 Hz ,2H, $CH_2$), 6.10 (br. s., 1H, $OH_{Ar}$), 6.48-6.56 (d, $J_{vicinal,trans}$ = 16.0 Hz, 1H, CH=CH), 6.53 (s, 1H, CH=CO), 6.91-6.97 (m, 1H, $CH_{Ar}$), 7.06-7.16 (m, 2H, $CH_{Ar}$), 7.64-7.72 (d, $J_{vicinal,trans}$ = 16.0 Hz, 1H, CH=CH) and 14.96 (br. s., 1H, OH). $^{13}$C NMR ($CDCl_3$, 50 MHz) δ (ppm) : 14.0, 55.9, 62.4, 100.5, 109.7, 114.9, 120.7, 123.8, 126.9, 143.7, 146.9, 148.7, 162.2, 173.0 and 185.9.

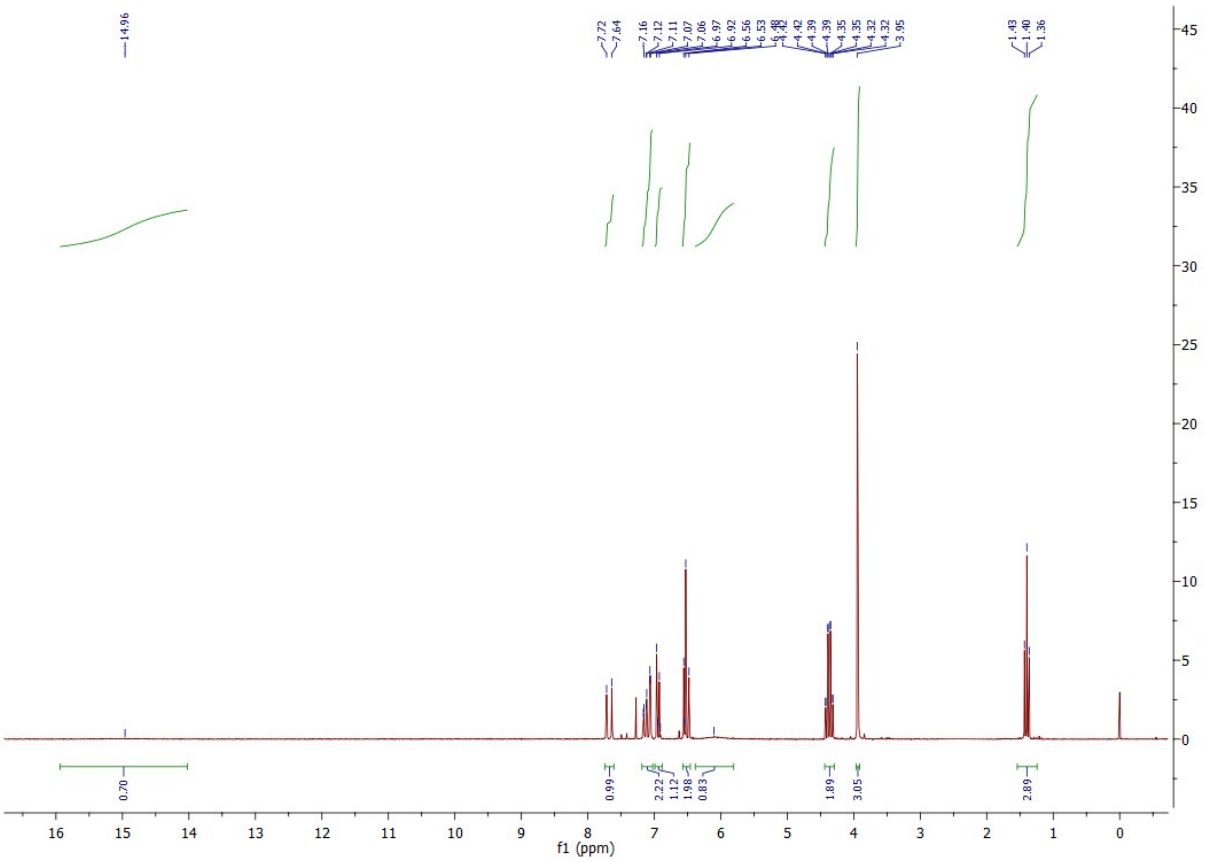



Fig. S8 $^{1}$H NMR spectrum of **2c**

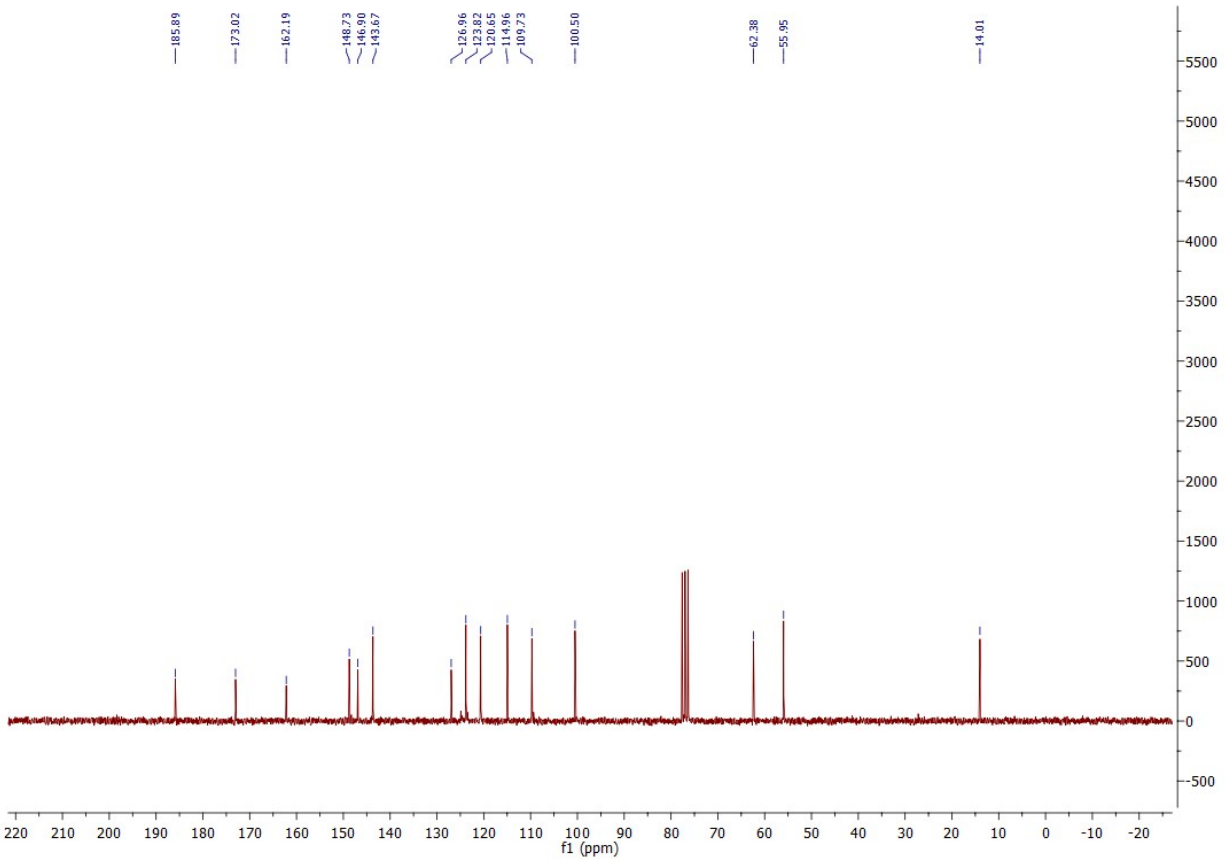
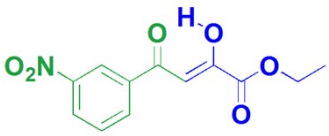



Fig. S9 $^{13}$C NMR spectrum of **2c**

ethyl 2-hydroxy-4-(3ʾ-nitrophenyl)-4-oxo-2-butenoate (**2d**)



$^1$H NMR ($CDCl_3$, 200 MHz) δ (ppm) : 1.40-1.48 (t, $J$ = 7.1 Hz, 3H, $CH_3$), 4.38-4.49 (q, $J$ = 7.1 Hz, 2H, $CH_2$), 7.13 (s, 1H, CH=CO), 7.75-7.79 (m, 1H, $CH_{Ar}$), 8.31-8.36 (m, 1H, $CH_{Ar}$), 8.44-8.50 (m, 1H, $CH_{Ar}$), 8.81-8.83 (m, 1H, $CH_{Ar}$) and 14.66 (br. s., 1H, OH). $^{13}$C NMR ($CDCl_3$, 50 MHz) δ (ppm): 14.0, 62.9, 97.8, 122.6, 127.7, 130.1, 133.2, 136.4, 148.6, 161.6, 171.3 and 187.5.

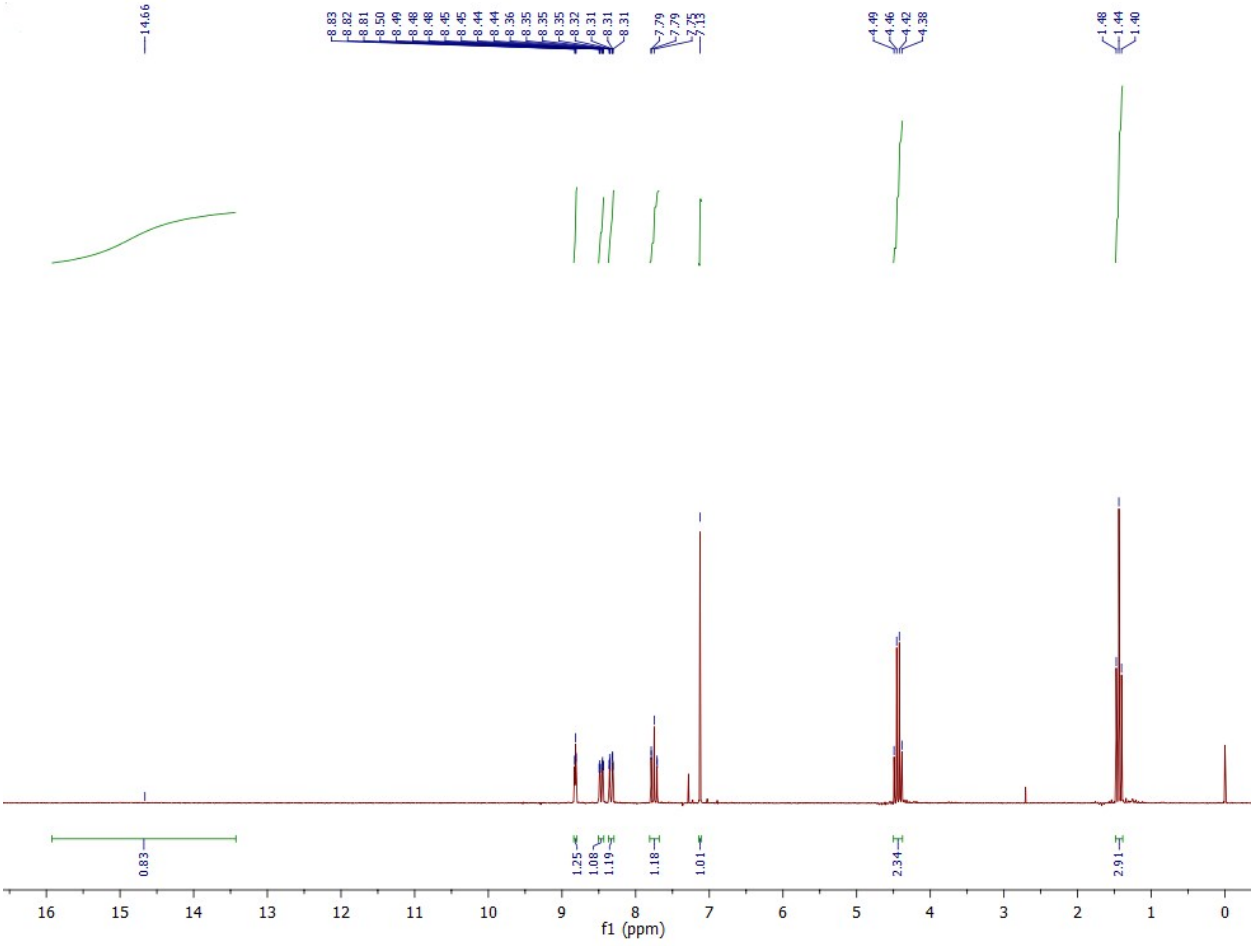



Fig. S10 $^1$H NMR spectrum of **2d**

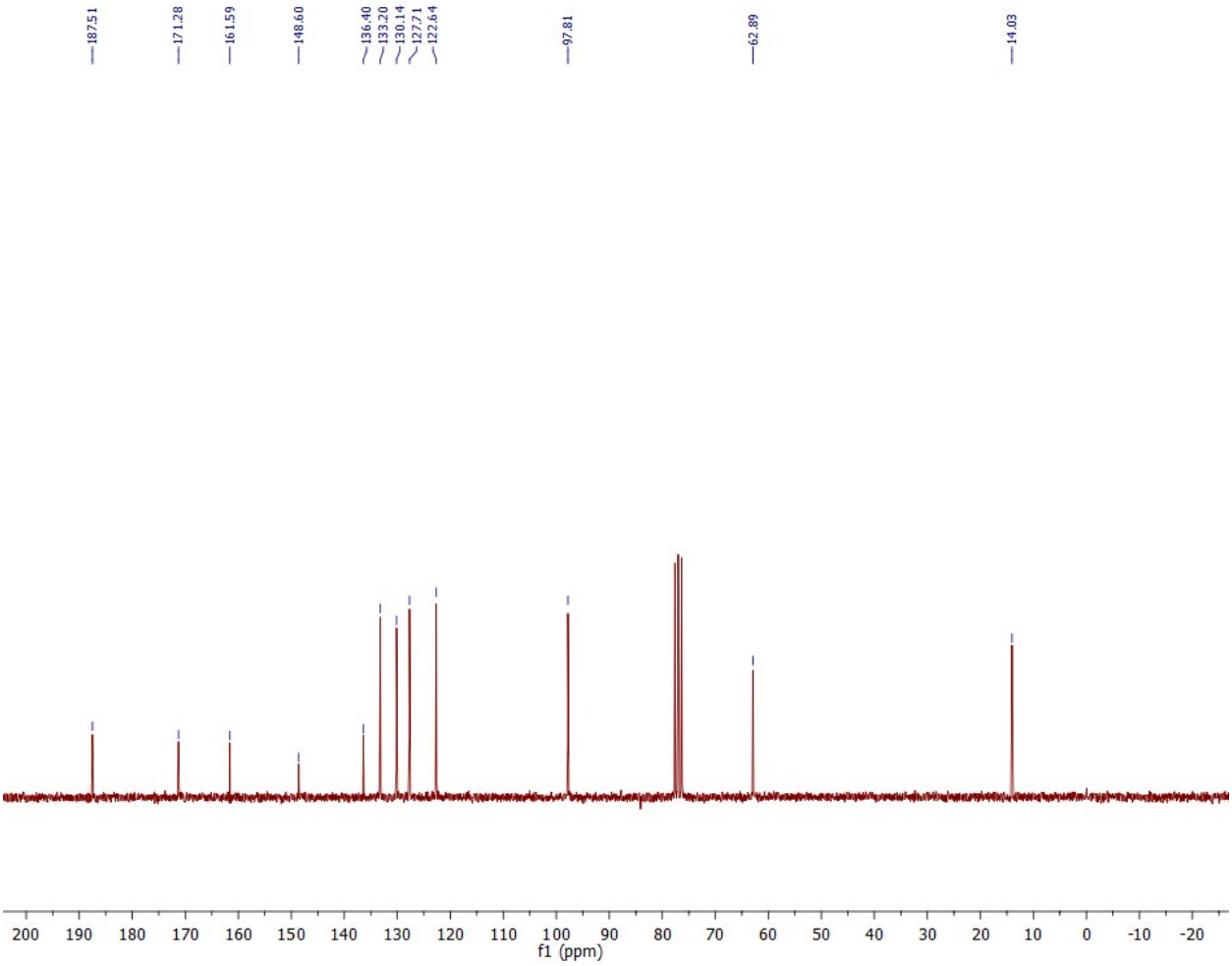
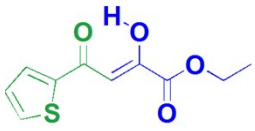



Fig. S11 $^{13}C$ NMR spectrum of **2d**

ethyl 2-hydroxy-4-(2'-thienyl)-4-oxo-2-butenoate **(2e)**



$^1$H NMR ($CDCl_3$, 200 MHz) δ (ppm) : 1.37-1.45 (t, $J$ = 7.0 Hz, 3H, $CH_3$), 4.35-4.45 (q, $J$ = 7.0 Hz, 2H, $CH_2$), 6.93 (s, 1H, CH=CO), 7.17-7.22 (m, 1H, $CH_{Ar}$), 7.74-7.87 (2×dd, 2H, $CH_{Ar}$), and 14.23 (br. s., 1H, OH). $^{13}$C NMR ($CDCl_3$, 50 MHz) δ (ppm): 14.0, 62.5, 99.4, 128.7, 132.5, 135.1, 142.1, 162.1, 164.9 and 186.0.

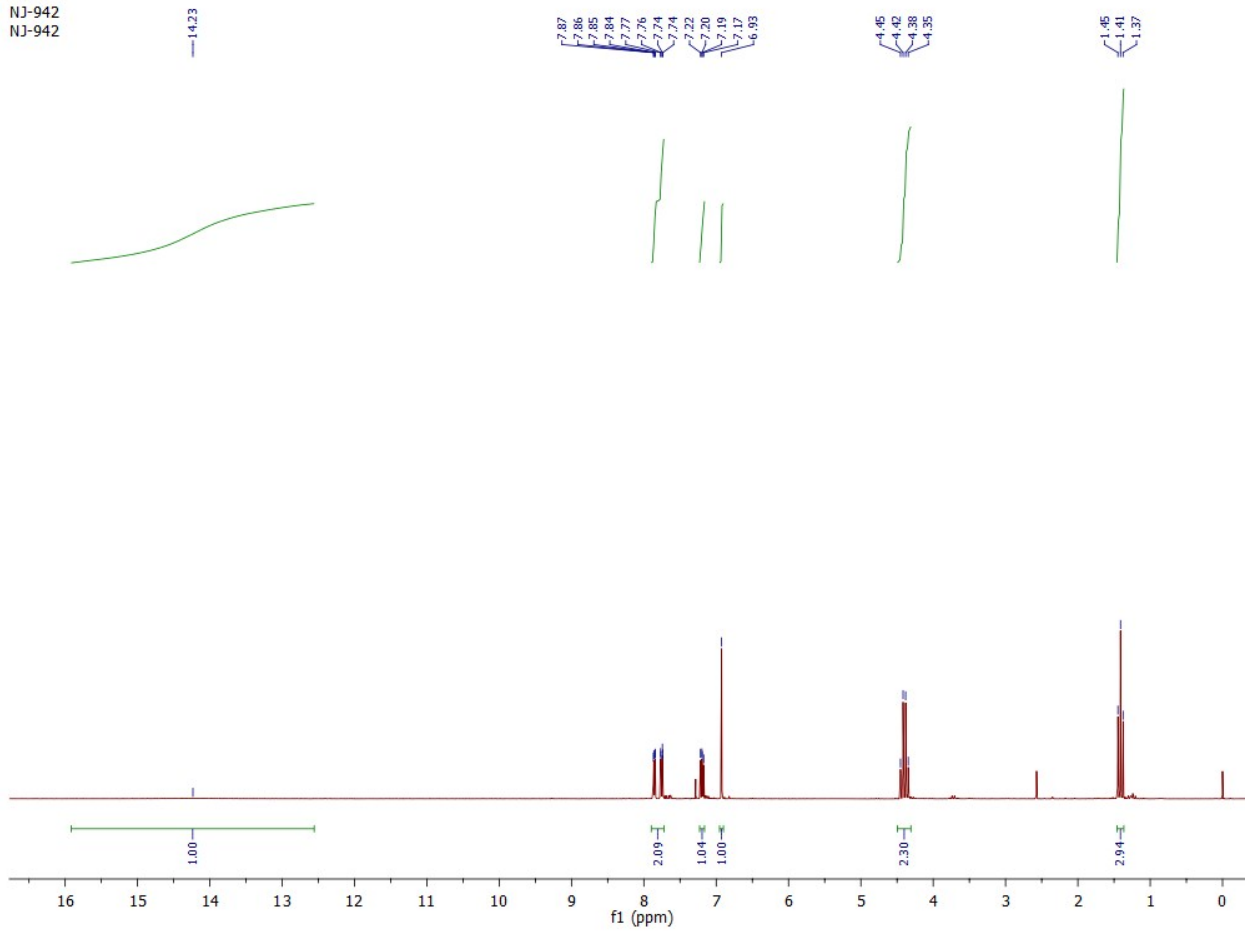



Fig. S12 $^1$H NMR spectrum of **2e**

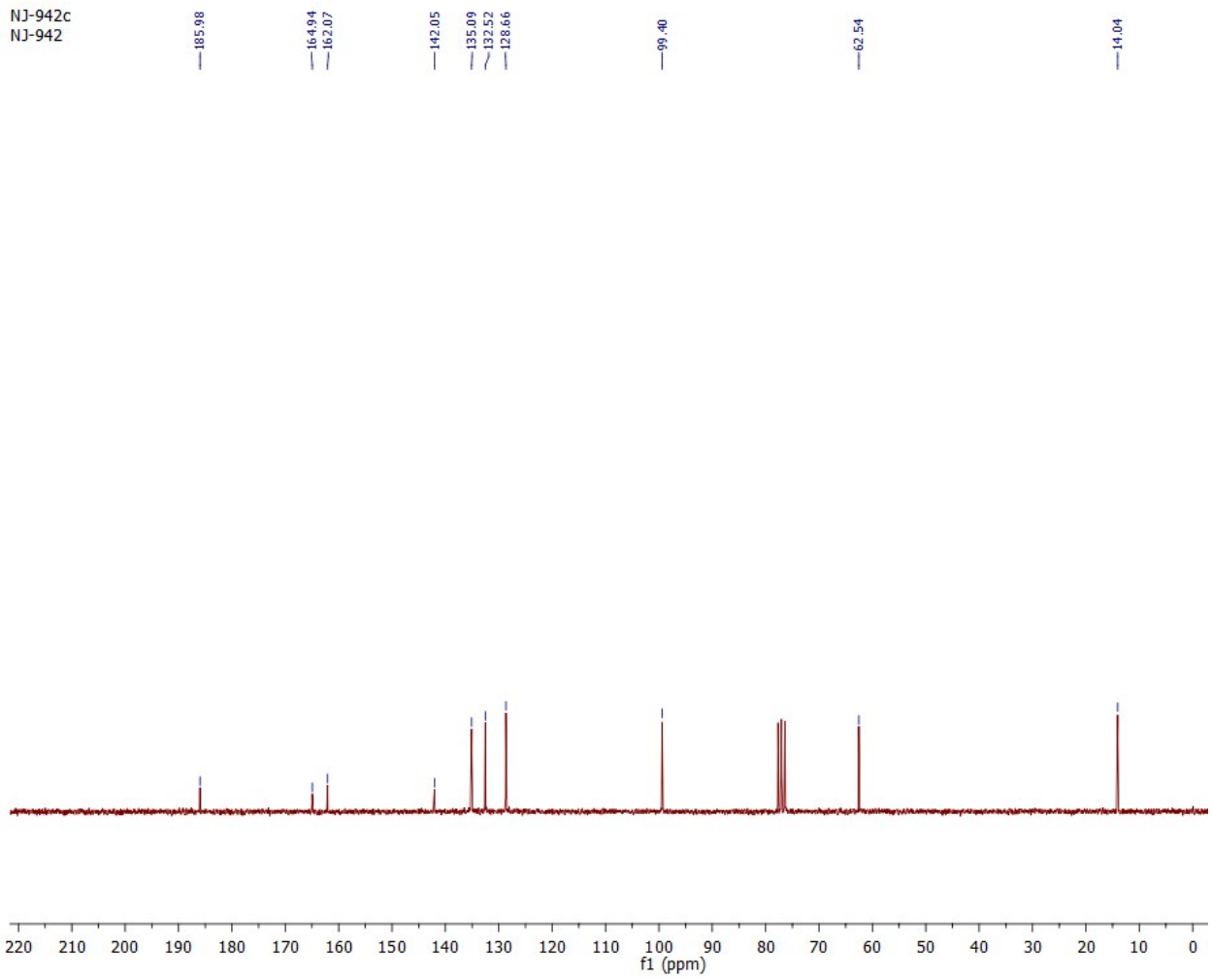



Fig. S13 $^{13}C$ NMR spectrum of **2e**

## 2. Crystallographic data of 3a

**Table S1**. Crystal data and structure refinement for Cu(II) complex

| | | |
|---|---|---|
| Empirical formula | $C_{26}H_{28}CuO_{11}$ | |
| Formula weight | 580.02 | |
| Temperature | 293(2) K | |
| Wavelength (Mo $K\alpha$) | 0.71073 Å | |
| Crystal system | Triclinic | |
| Space group | $P$ -1 | |
| Unit cell dimensions | $a$ = 8.8036(3) Å | $\alpha$ = 89.060(3)° |
| | $b$ = 11.6698(4) Å | $\beta$ = 85.122(3)° |
| | $c$ = 12.9590(5) Å | $\gamma$ = 89.476(3)° |
| Volume | 1326.32(8) $Å^3$ | |
| Z | 2 | |
| Density (calculated) | 1.452 $Mg/m^3$ | |
| Absorption coefficient | 0.883 $mm^{-1}$ | |
| F(000) | 602 | |
| Crystal size | 0.5493 x 0.1222 x 0.0730 $mm^3$ | |
| Theta range for data collection | 3.188 to 29.117°. | |
| Index ranges | -11<=h<=11, -14<=k<=14, -17<=l<=17 | |
| Reflections collected | 15602 | |
| Independent reflections | 6168 [$R_{(int)}$ = 0.0289] | |
| Completeness to theta = 26.000° | 99.6 % | |
| Absorption correction | Semi-empirical from equivalents | |
| Refinement method | Full-matrix least-squares on $F^2$ | |
| Data / restraints / parameters | 6168 / 0 / 349 | |
| Goodness-of-fit on $F^2$ | 1.118 | |
| Final R indices [I>2sigma(I)] | $R_1$ = 0.0455, $wR_2$ = 0.1269 | |
| R indices (all data) | $R_1$ = 0.0677, $wR_2$ = 0.1520 | |
| Largest diff. peak and hole | 0.594 and -0.656 $e.Å^{-3}$ | |

**Table S2**. Selected bond lengths (Å) and angles (°)

| Bond | A | B |
|---|---|---|
| Cu1−O3 | 1.920(2) | 1.927(2) |
| Cu1−O4 | 1.926(2) | 1.914(2) |
| Cu1−O1w | 2.371(2) | |
| C3−O1 | 1.312(4) | 1.323(3) |
| C3−O2 | 1.188(4) | 1.194(3) |
| C4−O3 | 1.271(3) | 1.273(3) |
| C6−O4 | 1.267(3) | 1.275(3) |
| C4−C5 | 1.386(4) | 1.382(3) |
| C5−C6 | 1.411(3) | 1.401(4) |
| Angle | A | B |
| O3−Cu1−O4 | 91.64(8) | 93.06(8) |
| O3−Cu1−O1w | 91.11(8) | 95.32(7) |
| O4−Cu1−O1w | 91.81(8) | 94.33(8) |
| O3a−Cu1−O4b | 173.92(8) | |
| O3b−Cu1−O4a | 172.81(8) | |
| O1−C3−O2 | 124.0(3) | 124.7(3) |
| C4−C5−O6 | 122.6(2) | 123.3(2) |

**Table S3**. Geometry of hydrogen bonding (Å, °)

| D−H…A | D−H | D…A | H…A | D−H…A |
|---|---|---|---|---|
| O1w−H1w…O2a$^{i}$ | 0.97 | 2.945(3) | 2.03 | 159 |
| O1w−H2w…O1b$^{i}$ | 0.83 | 3.212(3) | 2.55 | 137 |
| O1w−H1w…O3b$^{i}$ | 0.97 | 2.986(3) | 2.20 | 158 |
| O1w−H2w…O3a$^{i}$ | 0.83 | 2.999(3) | 2.38 | 122 |

Symmetry code: (i) -x+1,-y+1,-z+1

**Table S4**. Full list of bond lengths [Å] and angles [°] for Cu(II) complex

| | |
|---|---|
| Cu(1)-O(4B) | 1.9135(17) |
| Cu(1)-O(3A) | 1.9200(18) |
| Cu(1)-O(4A) | 1.9256(18) |
| Cu(1)-O(3B) | 1.9268(18) |
| Cu(1)-O(1W) | 2.3711(19) |
| O(1A)-C(3A) | 1.312(4) |
| O(1A)-C(2A) | 1.466(4) |
| O(1B)-C(3B) | 1.323(3) |
| O(1B)-C(2B) | 1.450(3) |

| | |
|---|---|
| O(2A)-C(3A) | 1.188(4) |
| O(2B)-C(3B) | 1.194(3) |
| O(3A)-C(4A) | 1.271(3) |
| O(3B)-C(4B) | 1.273(3) |
| O(4A)-C(6A) | 1.267(3) |
| O(4B)-C(6B) | 1.275(3) |
| O(5A)-C(9A) | 1.360(4) |
| O(5A)-C(13A) | 1.432(4) |
| O(5B)-C(9B) | 1.348(4) |
| O(5B)-C(13B) | 1.419(4) |
| C(1A)-C(2A) | 1.389(6) |
| C(1B)-C(2B) | 1.505(4) |
| C(3A)-C(4A) | 1.532(3) |
| C(3B)-C(4B) | 1.526(3) |
| C(4A)-C(5A) | 1.386(4) |
| C(4B)-C(5B) | 1.382(3) |
| C(5A)-C(6A) | 1.411(3) |
| C(5B)-C(6B) | 1.401(4) |
| C(6A)-C(7A) | 1.491(4) |
| C(6B)-C(7B) | 1.487(3) |
| C(7A)-C(12A) | 1.387(4) |
| C(7A)-C(8A) | 1.403(4) |
| C(7B)-C(8B) | 1.384(4) |
| C(7B)-C(12B) | 1.392(4) |
| C(8A)-C(9A) | 1.381(4) |
| C(8B)-C(9B) | 1.389(3) |
| C(9A)-C(10A) | 1.397(5) |
| C(9B)-C(10B) | 1.386(5) |
| C(10A)-C(11A) | 1.377(5) |
| C(10B)-C(11B) | 1.382(5) |
| C(11A)-C(12A) | 1.382(4) |
| C(11B)-C(12B) | 1.376(4) |

| | |
|---|---|
| O(4B)-Cu(1)-O(3A) | 173.92(8) |
| O(4B)-Cu(1)-O(4A) | 85.48(8) |
| O(3A)-Cu(1)-O(4A) | 91.64(8) |

| | |
|---|---|
| O(4B)-Cu(1)-O(3B) | 93.06(8) |
| O(3A)-Cu(1)-O(3B) | 89.13(8) |
| O(4A)-Cu(1)-O(3B) | 172.81(8) |
| O(4B)-Cu(1)-O(1W) | 94.33(8) |
| O(3A)-Cu(1)-O(1W) | 91.11(8) |
| O(4A)-Cu(1)-O(1W) | 91.81(8) |
| O(3B)-Cu(1)-O(1W) | 95.32(7) |
| C(3A)-O(1A)-C(2A) | 114.2(3) |
| C(3B)-O(1B)-C(2B) | 115.8(2) |
| C(4A)-O(3A)-Cu(1) | 122.80(17) |
| C(4B)-O(3B)-Cu(1) | 123.67(16) |
| C(6A)-O(4A)-Cu(1) | 126.23(17) |
| C(6B)-O(4B)-Cu(1) | 127.76(16) |
| C(9A)-O(5A)-C(13A) | 117.4(2) |
| C(9B)-O(5B)-C(13B) | 118.7(3) |
| C(1A)-C(2A)-O(1A) | 109.1(4) |
| O(1B)-C(2B)-C(1B) | 106.6(2) |
| O(2A)-C(3A)-O(1A) | 124.0(3) |
| O(2A)-C(3A)-C(4A) | 122.1(3) |
| O(1A)-C(3A)-C(4A) | 113.9(3) |
| O(2B)-C(3B)-O(1B) | 124.7(3) |
| O(2B)-C(3B)-C(4B) | 123.9(2) |
| O(1B)-C(3B)-C(4B) | 111.4(2) |
| O(3A)-C(4A)-C(5A) | 128.3(2) |
| O(3A)-C(4A)-C(3A) | 110.8(2) |
| C(5A)-C(4A)-C(3A) | 120.9(3) |
| O(3B)-C(4B)-C(5B) | 128.3(2) |
| O(3B)-C(4B)-C(3B) | 116.5(2) |
| C(5B)-C(4B)-C(3B) | 115.3(2) |
| C(4A)-C(5A)-C(6A) | 122.6(2) |
| C(4B)-C(5B)-C(6B) | 123.3(2) |
| O(4A)-C(6A)-C(5A) | 122.9(2) |
| O(4A)-C(6A)-C(7A) | 114.9(2) |
| C(5A)-C(6A)-C(7A) | 122.1(2) |
| O(4B)-C(6B)-C(5B) | 123.7(2) |
| O(4B)-C(6B)-C(7B) | 115.1(2) |

| | |
|---|---|
| C(5B)-C(6B)-C(7B) | 121.3(2) |
| C(12A)-C(7A)-C(8A) | 119.8(3) |
| C(12A)-C(7A)-C(6A) | 123.4(2) |
| C(8A)-C(7A)-C(6A) | 116.8(2) |
| C(8B)-C(7B)-C(12B) | 119.1(2) |
| C(8B)-C(7B)-C(6B) | 117.9(2) |
| C(12B)-C(7B)-C(6B) | 122.9(3) |
| C(9A)-C(8A)-C(7A) | 120.2(3) |
| C(7B)-C(8B)-C(9B) | 121.2(3) |
| O(5A)-C(9A)-C(8A) | 124.7(3) |
| O(5A)-C(9A)-C(10A) | 115.7(3) |
| C(8A)-C(9A)-C(10A) | 119.6(3) |
| O(5B)-C(9B)-C(10B) | 125.2(3) |
| O(5B)-C(9B)-C(8B) | 115.5(3) |
| C(10B)-C(9B)-C(8B) | 119.3(3) |
| C(11A)-C(10A)-C(9A) | 119.9(3) |
| C(11B)-C(10B)-C(9B) | 119.3(3) |
| C(10A)-C(11A)-C(12A) | 121.1(3) |
| C(12B)-C(11B)-C(10B) | 121.6(3) |
| C(11A)-C(12A)-C(7A) | 119.5(3) |
| C(11B)-C(12B)-C(7B) | 119.5(3) |

**Table S5**. Torsion angles [°] for Cu(II) complex

| | |
|---|---|
| C(3A)-O(1A)-C(2A)-C(1A) | 172.2(5) |
| C(3B)-O(1B)-C(2B)-C(1B) | 180.0(2) |
| C(2A)-O(1A)-C(3A)-O(2A) | 0.0(5) |
| C(2A)-O(1A)-C(3A)-C(4A) | -179.4(3) |
| C(2B)-O(1B)-C(3B)-O(2B) | 0.9(4) |
| C(2B)-O(1B)-C(3B)-C(4B) | -179.1(2) |
| Cu(1)-O(3A)-C(4A)-C(5A) | 11.7(4) |
| Cu(1)-O(3A)-C(4A)-C(3A) | -166.95(16) |
| O(2A)-C(3A)-C(4A)-O(3A) | 5.1(4) |
| O(1A)-C(3A)-C(4A)-O(3A) | -175.5(2) |

| | |
|---|---|
| O(2A)-C(3A)-C(4A)-C(5A) | -173.6(3) |
| O(1A)-C(3A)-C(4A)-C(5A) | 5.8(4) |
| Cu(1)-O(3B)-C(4B)-C(5B) | 5.2(4) |
| Cu(1)-O(3B)-C(4B)-C(3B) | -174.40(16) |
| O(2B)-C(3B)-C(4B)-O(3B) | -179.1(3) |
| O(1B)-C(3B)-C(4B)-O(3B) | 0.9(3) |
| O(2B)-C(3B)-C(4B)-C(5B) | 1.2(4) |
| O(1B)-C(3B)-C(4B)-C(5B) | -178.8(2) |
| O(3A)-C(4A)-C(5A)-C(6A) | 3.7(4) |
| C(3A)-C(4A)-C(5A)-C(6A) | -177.8(2) |
| O(3B)-C(4B)-C(5B)-C(6B) | -0.2(4) |
| C(3B)-C(4B)-C(5B)-C(6B) | 179.4(2) |
| Cu(1)-O(4A)-C(6A)-C(5A) | -18.7(4) |
| Cu(1)-O(4A)-C(6A)-C(7A) | 160.64(17) |
| C(4A)-C(5A)-C(6A)-O(4A) | -0.1(4) |
| C(4A)-C(5A)-C(6A)-C(7A) | -179.5(2) |
| Cu(1)-O(4B)-C(6B)-C(5B) | 0.0(4) |
| Cu(1)-O(4B)-C(6B)-C(7B) | -179.74(16) |
| C(4B)-C(5B)-C(6B)-O(4B) | -2.7(4) |
| C(4B)-C(5B)-C(6B)-C(7B) | 177.0(2) |
| O(4A)-C(6A)-C(7A)-C(12A) | -173.9(3) |
| C(5A)-C(6A)-C(7A)-C(12A) | 5.5(4) |
| O(4A)-C(6A)-C(7A)-C(8A) | 4.0(3) |
| C(5A)-C(6A)-C(7A)-C(8A) | -176.6(2) |
| O(4B)-C(6B)-C(7B)-C(8B) | -5.0(3) |
| C(5B)-C(6B)-C(7B)-C(8B) | 175.2(2) |
| O(4B)-C(6B)-C(7B)-C(12B) | 173.4(3) |
| C(5B)-C(6B)-C(7B)-C(12B) | -6.3(4) |
| C(12A)-C(7A)-C(8A)-C(9A) | -0.1(4) |
| C(6A)-C(7A)-C(8A)-C(9A) | -178.1(2) |
| C(12B)-C(7B)-C(8B)-C(9B) | -0.7(4) |
| C(6B)-C(7B)-C(8B)-C(9B) | 177.8(2) |
| C(13A)-O(5A)-C(9A)-C(8A) | -0.5(4) |
| C(13A)-O(5A)-C(9A)-C(10A) | 179.1(3) |
| C(7A)-C(8A)-C(9A)-O(5A) | -179.2(2) |
| C(7A)-C(8A)-C(9A)-C(10A) | 1.2(4) |

| | |
|---|---|
| C(13B)-O(5B)-C(9B)-C(10B) | -1.3(5) |
| C(13B)-O(5B)-C(9B)-C(8B) | 178.9(3) |
| C(7B)-C(8B)-C(9B)-O(5B) | 179.9(2) |
| C(7B)-C(8B)-C(9B)-C(10B) | 0.1(4) |
| O(5A)-C(9A)-C(10A)-C(11A) | 179.0(3) |
| C(8A)-C(9A)-C(10A)-C(11A) | -1.3(4) |
| O(5B)-C(9B)-C(10B)-C(11B) | -179.4(3) |
| C(8B)-C(9B)-C(10B)-C(11B) | 0.4(5) |
| C(9A)-C(10A)-C(11A)-C(12A) | 0.4(5) |
| C(9B)-C(10B)-C(11B)-C(12B) | -0.4(5) |
| C(10A)-C(11A)-C(12A)-C(7A) | 0.7(5) |
| C(8A)-C(7A)-C(12A)-C(11A) | -0.8(4) |
| C(6A)-C(7A)-C(12A)-C(11A) | 177.1(3) |
| C(10B)-C(11B)-C(12B)-C(7B) | -0.2(5) |
| C(8B)-C(7B)-C(12B)-C(11B) | 0.7(5) |
| C(6B)-C(7B)-C(12B)-C(11B) | -177.7(3) |