Electronic Supporting Information Materials

High anticancer activity and apoptosis- and autophagy-inducing properties of novel lanthanide(III) complexes bearing 8-hydroxyquinoline-N-oxide and 1,10-phenanthroline

Yan Yang [a,1], Zhen Zhou [a,1], Zu-Zhuang Wei [b,1], Qi-Pin Qin [a,c,*], Lin Yang [a] and Hong Liang [c,*]

Table S1. Crystal data and structure refinement details for **Ln1**.

Empirical formula	$C_{21}H_{16}Cl_2N_3O_3Sm$
Formula weight	579.62
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	9.9116(3)
b/Å	11.0963(3)
c/Å	18.2882(5)
α/°	90
β/°	92.574(2)
γ/°	90
Volume/Å^3	2009.35(10)
Z	4
ρ_{calc}g/cm^3	1.916
μ/mm^{-1}	3.218
F(000)	1132.0
Crystal size/mm^3	0.26 × 0.21 × 0.13
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	6.976 to 58.576
Index ranges	$-12 \le h \le 13$, $-11 \le k \le 14$, $-25 \le l \le 23$
Reflections collected	14048
Independent reflections	4851 [R_{int} = 0.0436, R_{sigma} = 0.0575]
Data/restraints/parameters	4851/3/279
Goodness-of-fit on F^2	1.043
Final R indexes [I>=2σ (I)]	R_1 = 0.0336, wR_2 = 0.0526
Final R indexes [all data]	R_1 = 0.0526, wR_2 = 0.0600
Largest diff. peak/hole / e Å^{-3}	0.76/-0.69

[a] $R_1 = \Sigma \, ||F_o| - |F_c|| / \Sigma |F_o|$; [b] $wR_2 = [\Sigma w(F_o^2 - F_c^2)^2 / \Sigma w(F_o^2)^2]^{1/2}$.

Table S2. Selected bond lengths (Å) for **Ln1**.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
Sm01	Cl1	2.7174(9)	C6	C5	1.434(5)
Sm01	Cl2	2.7200(10)	C6	C7	1.384(5)
Sm01	O1	2.212(3)	C14	C13	1.408(5)
Sm01	O3	2.483(3)	C5	C4	1.431(5)
Sm01	O2	2.257(3)	C10	C11	1.394(5)
Sm01	N3	2.612(3)	C7	C8	1.395(5)
Sm01	N2	2.616(3)	C1	C2	1.380(5)
O1	C6	1.310(4)	C3	C4	1.404(5)
O2	N1	1.319(4)	C3	C2	1.358(6)
N3	C21	1.323(4)	C20	C19	1.357(5)
N3	C18	1.359(4)	C19	C17	1.401(6)
N2	C14	1.365(4)	C4	C9	1.393(5)
N2	C10	1.326(4)	C13	C12	1.392(6)
N1	C5	1.389(5)	C13	C15	1.433(6)
N1	C1	1.333(5)	C17	C16	1.418(5)
C21	C20	1.395(5)	C16	C15	1.342(6)
C18	C14	1.443(5)	C8	C9	1.359(6)
C18	C17	1.406(5)	C12	C11	1.363(6)

Table S3. Selected bond angles (°) for **Ln1**.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
Cl1	Sm01	Cl2	160.25(3)	N3	C18	C17	122.5(4)
O1	Sm01	Cl1	106.99(7)	C17	C18	C14	119.0(4)
O1	Sm01	Cl2	92.25(7)	O1	C6	C5	123.2(3)
O1	Sm01	O3	140.71(9)	O1	C6	C7	119.6(4)
O1	Sm01	O2	72.52(9)	C7	C6	C5	117.1(4)
O1	Sm01	N3	138.15(10)	N2	C14	C18	117.9(3)
O1	Sm01	N2	75.43(9)	N2	C14	C13	122.7(4)
O3	Sm01	Cl1	88.41(7)	C13	C14	C18	119.4(4)
O3	Sm01	Cl2	79.05(8)	N1	C5	C6	122.5(3)
O3	Sm01	N3	79.34(10)	N1	C5	C4	117.3(3)
O3	Sm01	N2	141.39(10)	C4	C5	C6	120.2(4)
O2	Sm01	Cl1	88.92(7)	N2	C10	C11	124.6(4)
O2	Sm01	Cl2	101.38(7)	C6	C7	C8	122.0(4)
O2	Sm01	O3	71.87(10)	N1	C1	C2	121.5(4)
O2	Sm01	N3	149.17(10)	C2	C3	C4	120.9(4)
O2	Sm01	N2	146.74(10)	C19	C20	C21	118.8(4)
N3	Sm01	Cl1	79.37(6)	C20	C19	C17	120.2(4)
N3	Sm01	Cl2	83.33(6)	C3	C4	C5	118.8(4)

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
N3	Sm01	N2	62.90(10)	C9	C4	C5	119.2(4)
N2	Sm01	Cl1	92.08(7)	C9	C4	C3	122.0(4)
N2	Sm01	Cl2	88.42(7)	C3	C2	C1	119.4(4)
C6	O1	Sm01	139.4(2)	C14	C13	C15	119.4(4)
N1	O2	Sm01	140.3(2)	C12	C13	C14	118.0(4)
C21	N3	Sm01	122.1(3)	C12	C13	C15	122.6(4)
C21	N3	C18	117.8(3)	C18	C17	C16	119.6(4)
C18	N3	Sm01	120.1(2)	C19	C17	C18	117.1(4)
C14	N2	Sm01	120.1(2)	C19	C17	C16	123.2(4)
C10	N2	Sm01	123.4(3)	C15	C16	C17	121.8(4)
C10	N2	C14	116.5(3)	C9	C8	C7	121.1(4)
O2	N1	C5	121.3(3)	C11	C12	C13	119.6(4)
O2	N1	C1	116.6(3)	C8	C9	C4	120.4(4)
C1	N1	C5	122.0(3)	C12	C11	C10	118.6(4)
N3	C21	C20	123.5(4)	C16	C15	C13	120.6(4)
N3	C18	C14	118.4(3)				

Table S4. Crystal data and structure refinement details for **Ln2**.

Empirical formula	$C_{21}H_{16}Cl_2EuN_3O_3$
Formula weight	581.23
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	9.9054(3)
b/Å	11.1091(3)
c/Å	18.3023(7)
α/°	90
β/°	92.827(3)
γ/°	90
Volume/Å^3	2011.54(11)
Z	4
ρ_{calc}g/cm^3	1.919
μ/mm^{-1}	3.413
F(000)	1136.0
Crystal size/mm^3	0.35 × 0.25 × 0.16
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	6.962 to 58.342
Index ranges	$-13 \le h \le 12$, $-14 \le k \le 14$, $-24 \le l \le 24$
Reflections collected	14162
Independent reflections	4820 [R_{int} = 0.0376, R_{sigma} = 0.0475]
Data/restraints/parameters	4820/3/279

Goodness-of-fit on F^2	1.039
Final R indexes [I>=2σ (I)]	R_1 = 0.0320, wR_2 = 0.0603
Final R indexes [all data]	R_1 = 0.0457, wR_2 = 0.0674
Largest diff. peak/hole / e $Å^{-3}$	0.74/-1.21

[a] $R_1 = \Sigma ||F_o| - |F_c|| / \Sigma |F_o|$; [b] $wR_2 = [\Sigma w(F_o^2 - F_c^2)^2 / \Sigma w(F_o^2)^2]^{1/2}$.

Table S5. Selected bond lengths (Å) for **Ln2**.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
Eu1	Cl1	2.7073(10)	C4	C5	1.429(5)
Eu1	Cl2	2.7040(9)	C4	C12	1.417(5)
Eu1	O1	2.201(2)	C5	C6	1.337(6)
Eu1	O2	2.249(3)	C6	C7	1.434(6)
Eu1	O3	2.469(3)	C7	C8	1.386(6)
Eu1	N2	2.608(3)	C7	C11	1.415(5)
Eu1	N3	2.600(3)	C8	C9	1.365(6)
O1	C14	1.321(4)	C9	C10	1.386(5)
O2	N1	1.323(4)	C11	C12	1.436(5)
N1	C13	1.393(5)	C13	C14	1.419(5)
N1	C21	1.335(5)	C13	C18	1.433(5)
N2	C10	1.324(4)	C14	C15	1.393(5)
N2	C11	1.374(5)	C15	C16	1.401(5)
N3	C1	1.327(5)	C16	C17	1.359(6)
N3	C12	1.360(4)	C17	C18	1.403(5)
C1	C2	1.396(5)	C18	C19	1.400(6)
C2	C3	1.350(6)	C19	C20	1.361(6)
C3	C4	1.397(6)	C20	C21	1.395(5)

Table S6. Selected bond angles (°) for **Ln2**.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
Cl2	Eu1	Cl1	160.67(3)	C2	C3	C4	120.3(4)
O1	Eu1	Cl1	92.23(7)	C3	C4	C5	123.1(4)
O1	Eu1	Cl2	106.59(7)	C3	C4	C12	117.2(4)
O1	Eu1	O2	72.81(9)	C12	C4	C5	119.7(4)
O1	Eu1	O3	141.01(9)	C6	C5	C4	120.8(4)
O1	Eu1	N2	75.15(9)	C5	C6	C7	121.8(4)
O1	Eu1	N3	138.37(10)	C8	C7	C6	123.2(4)
O2	Eu1	Cl1	101.13(8)	C8	C7	C11	118.0(4)
O2	Eu1	Cl2	88.90(8)	C11	C7	C6	118.8(4)

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
O2	Eu1	O3	71.68(9)	C9	C8	C7	120.0(4)
O2	Eu1	N2	146.73(9)	C8	C9	C10	118.4(4)
O2	Eu1	N3	148.68(9)	N2	C10	C9	124.9(4)
O3	Eu1	Cl1	79.38(7)	N2	C11	C7	122.1(3)
O3	Eu1	Cl2	88.34(7)	N2	C11	C12	118.2(3)
O3	Eu1	N2	141.59(9)	C7	C11	C12	119.7(4)
O3	Eu1	N3	78.91(9)	N3	C12	C4	122.2(4)
N2	Eu1	Cl1	88.75(7)	N3	C12	C11	118.7(3)
N2	Eu1	Cl2	91.80(6)	C4	C12	C11	119.1(4)
N3	Eu1	Cl1	83.44(7)	N1	C13	C14	122.7(3)
N3	Eu1	Cl2	79.56(7)	N1	C13	C18	116.7(3)
N3	Eu1	N2	63.41(9)	C14	C13	C18	120.6(3)
C14	O1	Eu1	139.0(2)	O1	C14	C13	123.6(3)
N1	O2	Eu1	140.3(2)	O1	C14	C15	118.5(4)
O2	N1	C13	121.0(3)	C15	C14	C13	117.9(3)
O2	N1	C21	116.3(3)	C14	C15	C16	121.1(4)
C21	N1	C13	122.7(3)	C17	C16	C15	121.1(4)
C10	N2	Eu1	124.1(3)	C16	C17	C18	120.8(4)
C10	N2	C11	116.6(3)	C17	C18	C13	118.4(4)
C11	N2	Eu1	119.3(2)	C19	C18	C13	119.5(4)
C1	N3	Eu1	122.5(3)	C19	C18	C17	122.1(4)
C1	N3	C12	117.7(3)	C20	C19	C18	120.9(4)
C12	N3	Eu1	119.8(2)	C19	C20	C21	119.2(4)
N3	C1	C2	123.4(4)	N1	C21	C20	121.0(4)
C3	C2	C1	119.0(4)				

Table S7. Crystal data and structure refinement details for **Ln3**.

Empirical formula	$C_{21}H_{16}Cl_2GdN_3O_3$
Formula weight	586.52
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	9.8846(6)
b/Å	11.0552(6)
c/Å	18.2127(10)
α/°	90
β/°	93.014(2)
γ/°	90
Volume/Å^3	1987.5(2)
Z	4
ρ_{calc}g/cm^3	1.960

μ/mm^{-1}	3.636
F(000)	1140.0
Crystal size/mm^3	0.21 × 0.17 × 0.14
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	5.8 to 55.074
Index ranges	-12 ≤ h ≤ 12, -14 ≤ k ≤ 14, -23 ≤ l ≤ 23
Reflections collected	40606
Independent reflections	4574 [R_{int} = 0.0260, R_{sigma} = 0.0149]
Data/restraints/parameters	4574/0/272
Goodness-of-fit on F^2	1.020
Final R indexes [I>=2σ (I)]	R_1 = 0.0176, wR_2 = 0.0572
Final R indexes [all data]	R_1 = 0.0215, wR_2 = 0.0660
Largest diff. peak/hole / e Å^{-3}	0.44/-0.62

[a] $R_1 = \Sigma\, ||F_o| - |F_c||/\Sigma|F_o|$; [b] $wR_2 = [\Sigma w(F_o^2 - F_c^2)^2/\Sigma w(F_o^2)^2]^{½}$.

Table S8. Selected bond lengths (Å) for **Ln3**.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
Gd1	Cl2	2.6627(7)	C6	C7	1.391(4)
Gd1	Cl1	2.6709(8)	C17	C16	1.433(4)
Gd1	O2	2.1703(17)	C17	C18	1.335(5)
Gd1	O1	2.2292(18)	C2	C3	1.357(4)
Gd1	O3	2.4323(17)	C2	C1	1.398(4)
Gd1	N3	2.562(2)	C14	C15	1.435(4)
Gd1	N2	2.564(2)	C14	C13	1.415(4)
O2	C6	1.320(3)	C21	C20	1.396(4)
O1	N1	1.323(3)	C15	C16	1.412(3)
N1	C5	1.386(4)	C5	C4	1.426(3)
N1	C1	1.338(3)	C3	C4	1.414(4)
N3	C21	1.331(4)	C11	C10	1.403(4)
N3	C15	1.366(3)	C11	C12	1.366(5)
N2	C14	1.358(3)	C19	C16	1.398(4)
N2	C10	1.337(3)	C19	C20	1.354(5)
C9	C4	1.398(4)	C8	C7	1.390(4)
C9	C8	1.363(5)	C13	C18	1.446(4)
C6	C5	1.420(4)	C13	C12	1.394(5)

Table S9. Selected bond angles (°) for **Ln3**.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
Cl2	Gd1	Cl1	161.47(2)	O2	C6	C7	119.3(2)
O2	Gd1	Cl2	105.81(6)	C7	C6	C5	116.9(2)
O2	Gd1	Cl1	92.24(6)	C18	C17	C16	121.6(3)
O2	Gd1	O1	73.97(8)	C3	C2	C1	119.6(3)
O2	Gd1	O3	141.54(7)	N2	C14	C15	118.7(2)
O2	Gd1	N3	138.73(8)	N2	C14	C13	122.3(2)
O2	Gd1	N2	74.67(8)	C13	C14	C15	119.0(2)
O1	Gd1	Cl2	88.47(6)	N3	C21	C20	123.1(3)
O1	Gd1	Cl1	100.80(7)	N3	C15	C14	117.9(2)
O1	Gd1	O3	70.88(7)	N3	C15	C16	121.7(3)
O1	Gd1	N3	147.16(7)	C16	C15	C14	120.4(2)
O1	Gd1	N2	147.38(7)	N1	C5	C6	122.1(2)
O3	Gd1	Cl2	88.51(5)	N1	C5	C4	117.3(2)
O3	Gd1	Cl1	79.60(5)	C6	C5	C4	120.6(3)
O3	Gd1	N3	78.16(6)	C2	C3	C4	120.6(3)
O3	Gd1	N2	141.73(7)	C12	C11	C10	120.0(3)
N3	Gd1	Cl2	79.90(5)	N1	C1	C2	120.5(3)
N3	Gd1	Cl1	83.76(5)	C20	C19	C16	119.8(3)
N3	Gd1	N2	64.24(7)	C15	C16	C17	118.6(3)
N2	Gd1	Cl2	91.57(5)	C19	C16	C17	123.4(3)
N2	Gd1	Cl1	89.14(5)	C19	C16	C15	117.9(3)
C6	O2	Gd1	138.49(18)	C9	C4	C5	119.2(3)
N1	O1	Gd1	138.73(16)	C9	C4	C3	121.7(3)
O1	N1	C5	122.1(2)	C3	C4	C5	119.1(3)
O1	N1	C1	115.0(2)	C9	C8	C7	120.6(3)
C1	N1	C5	122.8(2)	C14	C13	C18	118.9(3)
C21	N3	Gd1	122.65(18)	C12	C13	C14	118.5(3)
C21	N3	C15	118.0(2)	C12	C13	C18	122.5(3)
C15	N3	Gd1	119.39(16)	C8	C7	C6	122.5(3)
C14	N2	Gd1	119.17(17)	C19	C20	C21	119.4(3)
C10	N2	Gd1	122.94(19)	N2	C10	C11	122.6(3)
C10	N2	C14	117.8(2)	C17	C18	C13	121.2(3)
C8	C9	C4	120.2(3)	C11	C12	C13	118.7(3)
O2	C6	C5	123.8(2)				

Table S10. Crystal data and structure refinement details for **Ln4**.

Empirical formula	$C_{21}H_{16}Cl_2DyN_3O_3$
Formula weight	591.77
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	9.8681(4)
b/Å	11.0471(4)
c/Å	18.2005(4)
α/°	90
β/°	93.009(3)
γ/°	90
Volume/Å^3	1981.36(11)
Z	4
ρ_{calc}g/cm^3	1.984
μ/mm^{-1}	4.071
F(000)	1148.0
Crystal size/mm^3	0.26 × 0.21 × 0.13
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	6.99 to 52.744
Index ranges	$-10 \le h \le 12$, $-13 \le k \le 13$, $-22 \le l \le 22$
Reflections collected	12454
Independent reflections	4054 [R_{int} = 0.0424, R_{sigma} = 0.0449]
Data/restraints/parameters	4054/9/279
Goodness-of-fit on F^2	1.061
Final R indexes [I>=2σ (I)]	R_1 = 0.0338, wR_2 = 0.0780
Final R indexes [all data]	R_1 = 0.0492, wR_2 = 0.0908
Largest diff. peak/hole / e Å^{-3}	1.71/-1.14

[a] $R_1 = \Sigma ||F_o| - |F_c|| / \Sigma |F_o|$; [b] $wR_2 = [\Sigma w(F_o^2 - F_c^2)^2 / \Sigma w(F_o^2)^2]^{1/2}$.

Table S11. Selected bond lengths (Å) for **Ln4**.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
Dy1	Cl1	2.6629(15)	C4	C5	1.419(7)
Dy1	Cl2	2.6578(14)	C4	C9	1.403(8)
Dy1	O1	2.429(4)	C5	C6	1.439(7)
Dy1	O2	2.222(3)	C6	C7	1.376(8)
Dy1	O3	2.164(3)	C7	C8	1.403(8)
Dy1	N1	2.555(4)	C8	C9	1.382(9)
Dy1	N2	2.562(4)	C10	C11	1.358(8)
O2	N3	1.329(5)	C11	C12	1.362(8)
O3	C6	1.313(6)	C12	C13	1.387(8)

Atom	Atom	Length/Å	Atom	Atom	Length/Å
N1	C19	1.317(7)	C13	C14	1.447(8)
N1	C20	1.367(6)	C13	C21	1.421(7)
N2	C10	1.323(6)	C14	C15	1.336(9)
N2	C21	1.368(7)	C15	C16	1.432(8)
N3	C1	1.337(6)	C16	C17	1.394(8)
N3	C5	1.369(7)	C16	C20	1.404(7)
C1	C2	1.401(8)	C17	C18	1.358(8)
C2	C3	1.356(8)	C18	C19	1.388(8)
C3	C4	1.406(8)	C20	C21	1.438(7)

Table S12. Selected bond angles (°) for **Ln4**.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
Cl2	Dy1	Cl1	161.36(5)	C2	C3	C4	120.4(5)
O1	Dy1	Cl1	79.43(11)	C3	C4	C5	119.0(5)
O1	Dy1	Cl2	88.65(11)	C9	C4	C3	121.2(5)
O1	Dy1	N1	78.06(13)	C9	C4	C5	119.8(5)
O1	Dy1	N2	141.82(14)	N3	C5	C4	118.0(5)
O2	Dy1	Cl1	100.78(12)	N3	C5	C6	122.0(4)
O2	Dy1	Cl2	88.56(12)	C4	C5	C6	119.9(5)
O2	Dy1	O1	70.75(14)	O3	C6	C5	123.1(5)
O2	Dy1	N1	146.86(14)	O3	C6	C7	119.4(5)
O2	Dy1	N2	147.43(14)	C7	C6	C5	117.4(5)
O3	Dy1	Cl1	92.32(11)	C6	C7	C8	122.9(6)
O3	Dy1	Cl2	105.84(11)	C9	C8	C7	119.7(6)
O3	Dy1	O1	141.21(13)	C8	C9	C4	120.2(5)
O3	Dy1	O2	73.82(14)	N2	C10	C11	127.2(6)
O3	Dy1	N1	139.17(14)	C10	C11	C12	118.1(6)
O3	Dy1	N2	74.83(14)	C11	C12	C13	119.1(5)
N1	Dy1	Cl1	83.87(10)	C12	C13	C14	123.8(5)
N1	Dy1	Cl2	79.64(10)	C12	C13	C21	118.7(5)
N1	Dy1	N2	64.50(14)	C21	C13	C14	117.6(6)
N2	Dy1	Cl1	89.02(10)	C15	C14	C13	122.2(6)
N2	Dy1	Cl2	91.66(10)	C14	C15	C16	120.9(6)
N3	O2	Dy1	138.9(3)	C17	C16	C15	122.4(5)
C6	O3	Dy1	139.2(3)	C17	C16	C20	117.8(5)
C19	N1	Dy1	123.6(4)	C20	C16	C15	119.6(6)
C19	N1	C20	117.0(5)	C18	C17	C16	119.5(5)
C20	N1	Dy1	119.4(3)	C17	C18	C19	118.9(6)
C10	N2	Dy1	125.7(4)	N1	C19	C18	124.3(6)

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
C10	N2	C21	115.2(5)	N1	C20	C16	122.3(5)
C21	N2	Dy1	119.0(3)	N1	C20	C21	118.2(4)
O2	N3	C1	114.9(4)	C16	C20	C21	119.5(5)
O2	N3	C5	122.2(4)	N2	C21	C13	121.6(5)
C1	N3	C5	122.8(5)	N2	C21	C20	118.2(4)
N3	C1	C2	120.0(6)	C13	C21	C20	120.1(5)
C3	C2	C1	119.8(5)				

Table S13. Crystal data and structure refinement details for **Ln5**.

Empirical formula	$C_{21}H_{16}Cl_2HoN_3O_3$
Formula weight	594.20
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	9.8801(6)
b/Å	11.0521(7)
c/Å	18.2125(11)
α/°	90
β/°	93.202(2)
γ/°	90
Volume/Å^3	1985.6(2)
Z	4
ρ_{calc}g/cm^3	1.988
μ/mm^{-1}	4.284
F(000)	1152.0
Crystal size/mm^3	0.22 × 0.17 × 0.11
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	5.802 to 55.08
Index ranges	$-12 \le h \le 12$, $-14 \le k \le 14$, $-23 \le l \le 23$
Reflections collected	30363
Independent reflections	4568 [R_{int} = 0.0279, R_{sigma} = 0.0198]
Data/restraints/parameters	4568/3/279
Goodness-of-fit on F^2	1.034
Final R indexes [I>=2σ (I)]	R_1 = 0.0213, wR_2 = 0.0480
Final R indexes [all data]	R_1 = 0.0257, wR_2 = 0.0495
Largest diff. peak/hole / e Å^{-3}	1.36/-0.89

[a] $R_1 = \Sigma ||F_o| - |F_c||/\Sigma|F_o|$; [b] $wR_2 = [\Sigma w(F_o^2 - F_c^2)^2/\Sigma w(F_o^2)^2]^{½}$.

Table S14. Selected bond lengths (Å) for **Ln5**.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
Ho1	Cl1	2.6457(7)	C3	C4	1.411(5)
Ho1	Cl2	2.6554(8)	C5	C6	1.425(4)
Ho1	O3	2.418(2)	C5	C4	1.433(4)
Ho1	O2	2.1605(19)	C21	C20	1.398(4)
Ho1	O1	2.217(2)	C17	C16	1.429(5)
Ho1	N3	2.553(2)	C17	C18	1.336(5)
Ho1	N2	2.549(2)	C14	C13	1.410(4)
O2	C6	1.313(3)	C6	C7	1.387(4)
O1	N1	1.327(3)	C16	C19	1.400(5)
N3	C15	1.362(3)	C1	C2	1.391(4)
N3	C21	1.323(4)	C9	C4	1.400(5)
N1	C5	1.381(4)	C9	C8	1.365(5)
N1	C1	1.334(4)	C19	C20	1.358(5)
N2	C14	1.365(4)	C7	C8	1.387(5)
N2	C10	1.330(4)	C18	C13	1.436(5)
C15	C14	1.435(4)	C13	C12	1.395(5)
C15	C16	1.410(4)	C10	C11	1.398(4)
C3	C2	1.354(5)	C12	C11	1.370(5)

Table S15. Selected bond angles (°) for **Ln5**.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
Cl1	Ho1	Cl2	161.81(3)	C16	C15	C14	119.5(3)
O3	Ho1	Cl1	88.71(6)	C2	C3	C4	120.6(3)
O3	Ho1	Cl2	79.71(6)	N1	C5	C6	122.4(2)
O3	Ho1	N3	77.95(7)	N1	C5	C4	117.2(3)
O3	Ho1	N2	141.90(7)	C6	C5	C4	120.4(3)
O2	Ho1	Cl1	105.40(6)	N3	C21	C20	123.2(3)
O2	Ho1	Cl2	92.29(6)	C18	C17	C16	121.1(3)
O2	Ho1	O3	141.50(8)	N2	C14	C15	118.0(2)
O2	Ho1	O1	74.21(8)	N2	C14	C13	122.6(3)
O2	Ho1	N3	139.05(8)	C13	C14	C15	119.3(3)
O2	Ho1	N2	74.65(8)	O2	C6	C5	123.4(2)
O1	Ho1	Cl1	88.33(7)	O2	C6	C7	119.7(3)
O1	Ho1	Cl2	100.78(7)	C7	C6	C5	116.9(3)
O1	Ho1	O3	70.54(7)	C15	C16	C17	119.4(3)
O1	Ho1	N3	146.60(8)	C19	C16	C15	117.8(3)
O1	Ho1	N2	147.56(8)	C19	C16	C17	122.8(3)
N3	Ho1	Cl1	80.02(5)	N1	C1	C2	120.8(3)
N3	Ho1	Cl2	83.85(5)	C8	C9	C4	120.2(3)

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
N2	Ho1	Cl1	91.28(6)	C20	C19	C16	119.6(3)
N2	Ho1	Cl2	89.33(6)	C3	C2	C1	119.7(3)
N2	Ho1	N3	64.57(7)	C19	C20	C21	119.2(3)
C6	O2	Ho1	138.78(18)	C3	C4	C5	118.9(3)
N1	O1	Ho1	138.66(17)	C9	C4	C3	122.1(3)
C15	N3	Ho1	119.02(18)	C9	C4	C5	119.0(3)
C21	N3	Ho1	122.96(19)	C6	C7	C8	122.7(3)
C21	N3	C15	118.0(2)	C17	C18	C13	121.3(3)
O1	N1	C5	121.8(2)	C14	C13	C18	119.2(3)
O1	N1	C1	115.5(2)	C12	C13	C14	118.1(3)
C1	N1	C5	122.7(2)	C12	C13	C18	122.7(3)
C14	N2	Ho1	119.32(18)	C9	C8	C7	120.7(3)
C10	N2	Ho1	123.5(2)	N2	C10	C11	123.7(3)
C10	N2	C14	117.1(3)	C11	C12	C13	119.2(3)
N3	C15	C14	118.5(2)	C12	C11	C10	119.2(3)
N3	C15	C16	122.0(3)				

Table S16. Crystal data and structure refinement details for **Ln6**.

Empirical formula	$C_{21}H_{16}Cl_2ErN_3O_3$
Formula weight	596.53
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	9.8863(6)
b/Å	11.0534(14)
c/Å	18.1992(12)
α/°	90
β/°	93.259(6)
γ/°	90
Volume/Å^3	1985.5(3)
Z	4
ρ_{calc}g/cm^3	1.996
μ/mm^{-1}	4.525
F(000)	1156.0
Crystal size/mm^3	0.36 × 0.25 × 0.19
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	6.974 to 58.164
Index ranges	$-13 \le h \le 12$, $-15 \le k \le 14$, $-24 \le l \le 24$
Reflections collected	13513
Independent reflections	4723 [R_{int} = 0.0443, R_{sigma} = 0.0544]
Data/restraints/parameters	4723/0/272

Goodness-of-fit on F^2	1.087
Final R indexes [I>=2σ (I)]	R_1 = 0.0357, wR_2 = 0.0710
Final R indexes [all data]	R_1 = 0.0495, wR_2 = 0.0842
Largest diff. peak/hole / e Å^{-3}	1.63/-1.21

[a] $R_1 = \Sigma \, ||F_o| - |F_c|| / \Sigma |F_o|$; [b] $wR_2 = [\Sigma w(F_o^2 - F_c^2)^2 / \Sigma w(F_o^2)^2]^{1/2}$.

Table S17. Selected bond lengths (Å) for **Ln6**.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
Er1	Cl1	2.6359(14)	C4	C5	1.411(8)
Er1	Cl2	2.6466(14)	C4	C9	1.429(7)
Er1	O1	2.157(3)	C5	C6	1.347(9)
Er1	O2	2.204(3)	C6	C7	1.396(8)
Er1	O3	2.414(3)	C7	C8	1.384(7)
Er1	N2	2.539(4)	C8	C9	1.414(7)
Er1	N3	2.540(4)	C10	C11	1.372(7)
O1	C8	1.316(6)	C11	C12	1.374(8)
O2	N1	1.324(5)	C12	C13	1.404(8)
N1	C1	1.328(6)	C13	C14	1.440(8)
N1	C9	1.405(6)	C13	C21	1.403(7)
N2	C10	1.332(6)	C14	C15	1.338(8)
N2	C21	1.368(6)	C15	C16	1.434(7)
N3	C19	1.332(6)	C16	C17	1.398(8)
N3	C20	1.354(6)	C16	C20	1.416(7)
C1	C2	1.392(7)	C17	C18	1.348(8)
C2	C3	1.348(8)	C18	C19	1.406(7)
C3	C4	1.411(7)	C20	C21	1.448(7)

Table S18. Selected bond angles (°) for **Ln6**.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
Cl1	Er1	Cl2	162.18(5)	C2	C3	C4	121.4(5)
O1	Er1	Cl1	105.28(11)	C3	C4	C5	122.5(5)
O1	Er1	Cl2	92.03(11)	C3	C4	C9	118.6(5)
O1	Er1	O2	74.28(13)	C5	C4	C9	118.9(5)
O1	Er1	O3	141.67(12)	C6	C5	C4	119.9(5)
O1	Er1	N2	74.45(13)	C5	C6	C7	121.0(5)
O1	Er1	N3	139.21(13)	C8	C7	C6	122.6(5)
O2	Er1	Cl1	88.42(11)	O1	C8	C7	119.6(5)
O2	Er1	Cl2	100.57(12)	O1	C8	C9	123.6(4)

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
O2	Er1	O3	70.57(12)	C7	C8	C9	116.7(5)
O2	Er1	N2	147.44(14)	N1	C9	C4	117.1(5)
O2	Er1	N3	146.38(13)	N1	C9	C8	122.0(4)
O3	Er1	Cl1	88.69(10)	C8	C9	C4	120.8(5)
O3	Er1	Cl2	80.00(10)	N2	C10	C11	125.5(6)
O3	Er1	N2	141.98(13)	C10	C11	C12	118.7(6)
O3	Er1	N3	77.65(12)	C11	C12	C13	118.9(5)
N2	Er1	Cl1	91.24(10)	C12	C13	C14	122.4(5)
N2	Er1	Cl2	89.33(10)	C21	C13	C12	118.0(5)
N2	Er1	N3	64.94(13)	C21	C13	C14	119.6(6)
N3	Er1	Cl1	80.01(10)	C15	C14	C13	121.1(6)
N3	Er1	Cl2	84.11(10)	C14	C15	C16	121.0(5)
C8	O1	Er1	138.9(3)	C17	C16	C15	123.2(5)
N1	O2	Er1	139.2(3)	C17	C16	C20	117.0(5)
O2	N1	C1	116.8(4)	C20	C16	C15	119.8(5)
O2	N1	C9	121.3(4)	C18	C17	C16	120.7(5)
C1	N1	C9	121.9(4)	C17	C18	C19	118.6(5)
C10	N2	Er1	124.9(4)	N3	C19	C18	123.5(5)
C10	N2	C21	115.9(5)	N3	C20	C16	122.7(5)
C21	N2	Er1	119.2(3)	N3	C20	C21	118.5(4)
C19	N3	Er1	123.4(3)	C16	C20	C21	118.7(5)
C19	N3	C20	117.4(4)	N2	C21	C13	122.9(5)
C20	N3	Er1	119.2(3)	N2	C21	C20	117.5(4)
N1	C1	C2	121.6(5)	C13	C21	C20	119.6(5)
C3	C2	C1	119.2(5)				

Table S19. Crystal data and structure refinement details for **Ln7**.

Empirical formula	$C_{21}H_{16}Cl_2N_3O_3Yb$
Formula weight	602.31
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	9.87834(18)
b/Å	11.02546(19)
c/Å	18.1528(3)
α/°	90
β/°	93.2424(15)
γ/°	90
Volume/Å^3	1973.92(6)
Z	4
ρ_{calc}g/cm^3	2.027

μ/mm^{-1}	5.038
F(000)	1164.0
Crystal size/mm^3	0.28 × 0.21 × 0.15
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	6.988 to 58.352
Index ranges	-12 ≤ h ≤ 11, -14 ≤ k ≤ 15, -24 ≤ l ≤ 22
Reflections collected	13881
Independent reflections	4716 [R_{int} = 0.0444, R_{sigma} = 0.0509]
Data/restraints/parameters	4716/0/272
Goodness-of-fit on F^2	1.041
Final R indexes [I>=2σ (I)]	R_1 = 0.0315, wR_2 = 0.0617
Final R indexes [all data]	R_1 = 0.0450, wR_2 = 0.0689
Largest diff. peak/hole / e Å^{-3}	1.15/-0.92

[a] $R_1 = \Sigma ||F_o| - |F_c||/\Sigma|F_o|$; [b] $wR_2 = [\Sigma w(F_o^2 - F_c^2)^2/\Sigma w(F_o^2)^2]^{½}$.

Table S20. Selected bond lengths (Å) for **Ln7**.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
Yb1	Cl1	2.6194(10)	C4	C5	1.405(6)
Yb1	Cl2	2.6302(11)	C4	C5AA	1.423(5)
Yb1	O1	2.391(3)	C5	C6	1.364(7)
Yb1	O2	2.194(3)	C5AA	C8	1.425(6)
Yb1	O3	2.136(3)	C6	C7	1.399(6)
Yb1	N1	2.524(3)	C7	C8	1.381(6)
Yb1	N2	2.520(3)	C9	C10	1.383(6)
O2	N3	1.321(4)	C10	C11	1.368(6)
O3	C8	1.316(5)	C11	C12	1.390(6)
N1	C18	1.326(5)	C12	C13	1.444(6)
N1	C19	1.357(5)	C12	C20	1.419(6)
N2	C9	1.332(5)	C13	C14	1.332(7)
N2	C20	1.369(5)	C14	C15	1.434(6)
N3	C1	1.343(5)	C15	C16	1.414(6)
N3	C5AA	1.396(5)	C15	C19	1.407(5)
C1	C2	1.391(6)	C16	C17	1.352(6)
C2	C3	1.361(6)	C17	C18	1.385(6)
C3	C4	1.398(6)	C19	C20	1.447(5)

Table S21. Selected bond angles (°) for **Ln7**.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
Cl1	Yb1	Cl2	162.27(4)	C2	C3	C4	120.6(4)
O1	Yb1	Cl1	88.57(7)	C3	C4	C5	121.8(4)
O1	Yb1	Cl2	80.05(7)	C3	C4	C5AA	119.4(4)
O1	Yb1	N1	77.24(10)	C5	C4	C5AA	118.9(4)
O1	Yb1	N2	142.10(10)	C6	C5	C4	119.9(4)
O2	Yb1	Cl1	88.15(9)	N3	C5AA	C4	117.4(4)
O2	Yb1	Cl2	100.56(9)	N3	C5AA	C8	121.5(4)
O2	Yb1	O1	70.25(10)	C4	C5AA	C8	121.1(4)
O2	Yb1	N1	145.68(11)	C5	C6	C7	121.0(4)
O2	Yb1	N2	147.64(11)	C8	C7	C6	122.1(4)
O3	Yb1	Cl1	105.23(9)	O3	C8	C5AA	123.2(4)
O3	Yb1	Cl2	92.03(9)	O3	C8	C7	119.8(4)
O3	Yb1	O1	141.73(10)	C7	C8	C5AA	117.0(4)
O3	Yb1	O2	74.65(11)	N2	C9	C10	124.9(5)
O3	Yb1	N1	139.55(11)	C11	C10	C9	119.0(5)
O3	Yb1	N2	74.29(11)	C10	C11	C12	119.2(4)
N1	Yb1	Cl1	80.21(8)	C11	C12	C13	123.0(4)
N1	Yb1	Cl2	84.01(8)	C11	C12	C20	118.4(4)
N2	Yb1	Cl1	91.38(8)	C20	C12	C13	118.6(4)
N2	Yb1	Cl2	89.39(8)	C14	C13	C12	121.6(4)
N2	Yb1	N1	65.45(11)	C13	C14	C15	121.0(4)
N3	O2	Yb1	138.5(2)	C16	C15	C14	123.2(4)
C8	O3	Yb1	139.2(3)	C19	C15	C14	120.2(4)
C18	N1	Yb1	123.8(3)	C19	C15	C16	116.6(4)
C18	N1	C19	117.0(4)	C17	C16	C15	119.6(4)
C19	N1	Yb1	119.2(3)	C16	C17	C18	119.5(5)
C9	N2	Yb1	124.9(3)	N1	C18	C17	123.8(4)
C9	N2	C20	116.4(4)	N1	C19	C15	123.3(4)
C20	N2	Yb1	118.7(3)	N1	C19	C20	117.9(4)
O2	N3	C1	115.9(4)	C15	C19	C20	118.8(4)
O2	N3	C5AA	122.1(3)	N2	C20	C12	122.1(4)
C1	N3	C5AA	121.9(4)	N2	C20	C19	118.1(4)
N3	C1	C2	120.6(4)	C12	C20	C19	119.7(4)
C3	C2	C1	119.9(4)				

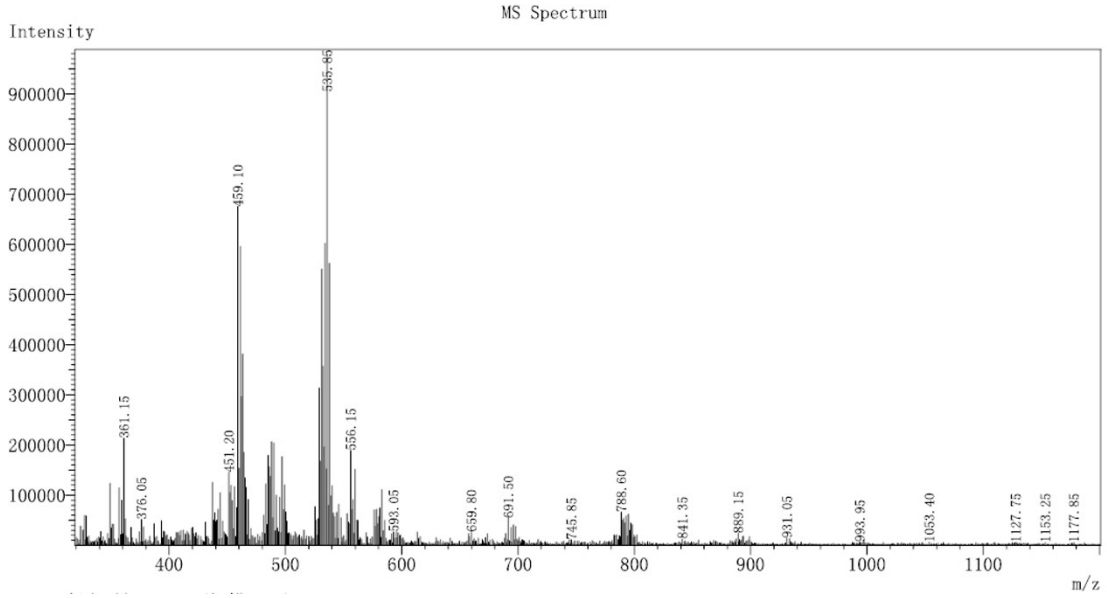


Figure S1. ESI-MS spectra of **Ln1** (2.0×10^{-5} M) in Tris-HCl buffer solution (containing 5% DMSO) for 0 h.

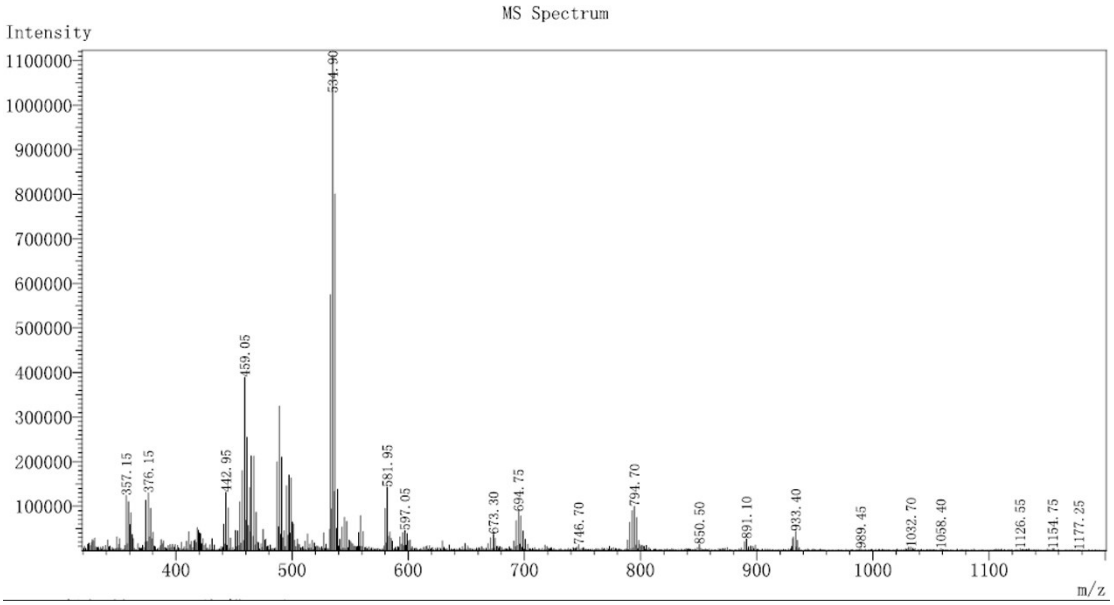


Figure S2. ESI-MS spectra of **Ln2** (2.0×10^{-5} M) in Tris-HCl buffer solution (containing 5% DMSO) for 0 h.

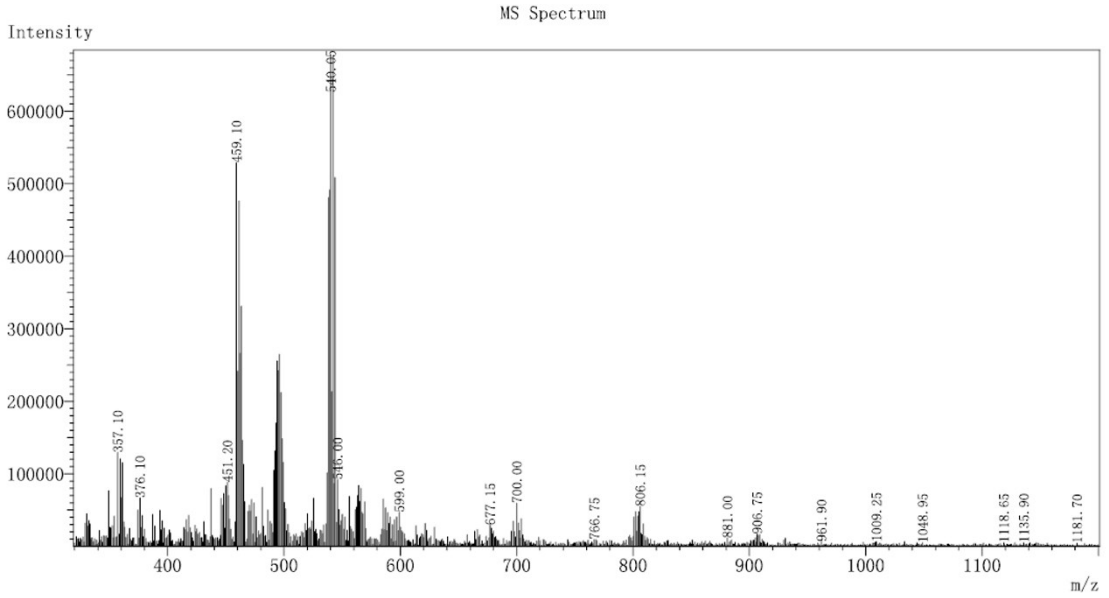


Figure S3. ESI-MS spectra of **Ln3** (2.0×10^{-5} M) in Tris-HCl buffer solution (containing 5% DMSO) for 0 h.

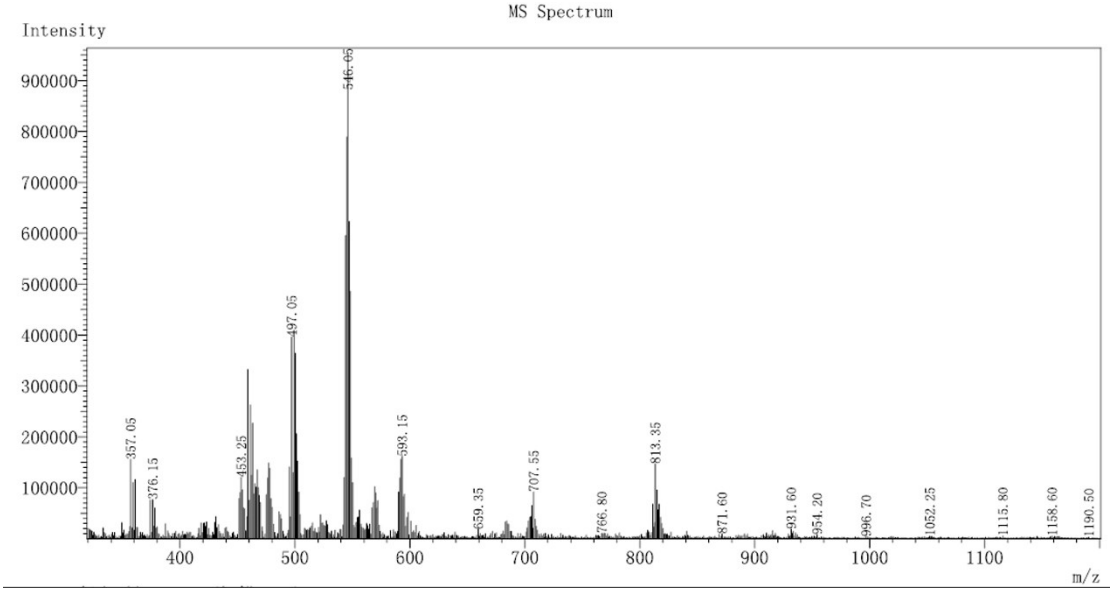


Figure S4. ESI-MS spectra of **Ln4** (2.0×10^{-5} M) in Tris-HCl buffer solution (containing 5% DMSO) for 0 h.

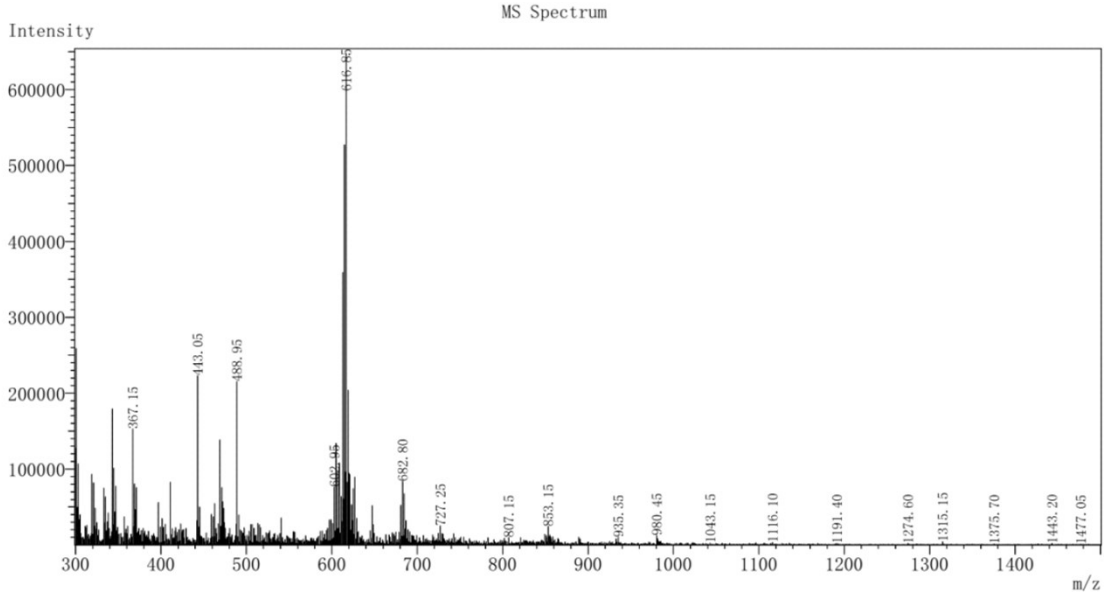


Figure S5. ESI-MS spectra of **Ln5** (2.0×10^{-5} M) in Tris-HCl buffer solution (containing 5% DMSO) for 0 h.

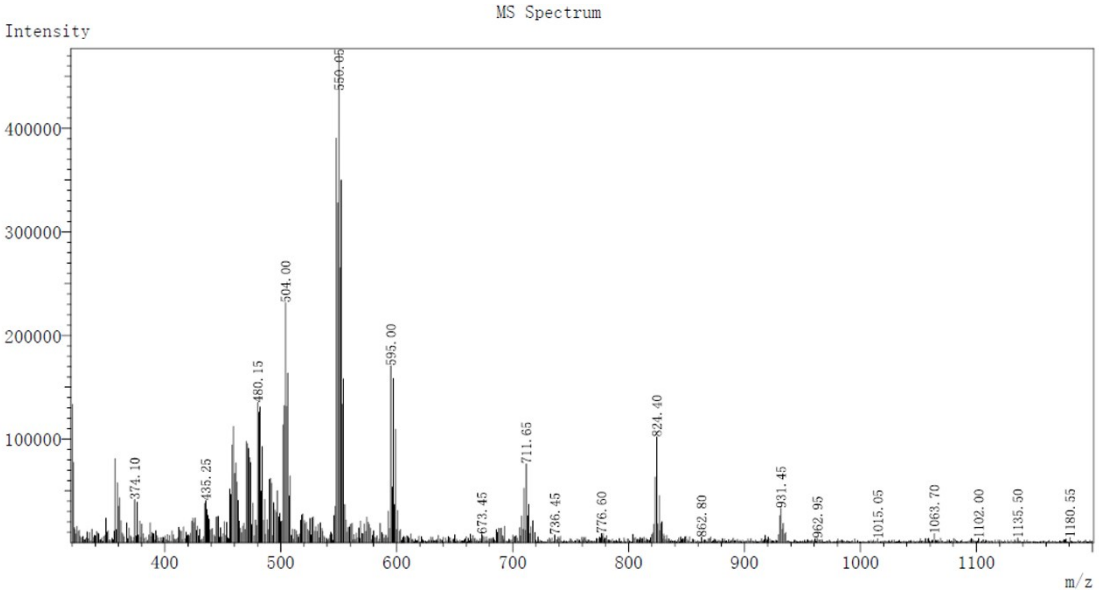


Figure S6. ESI-MS spectra of **Ln6** (2.0×10^{-5} M) in Tris-HCl buffer solution (containing 5% DMSO) for 0 h.

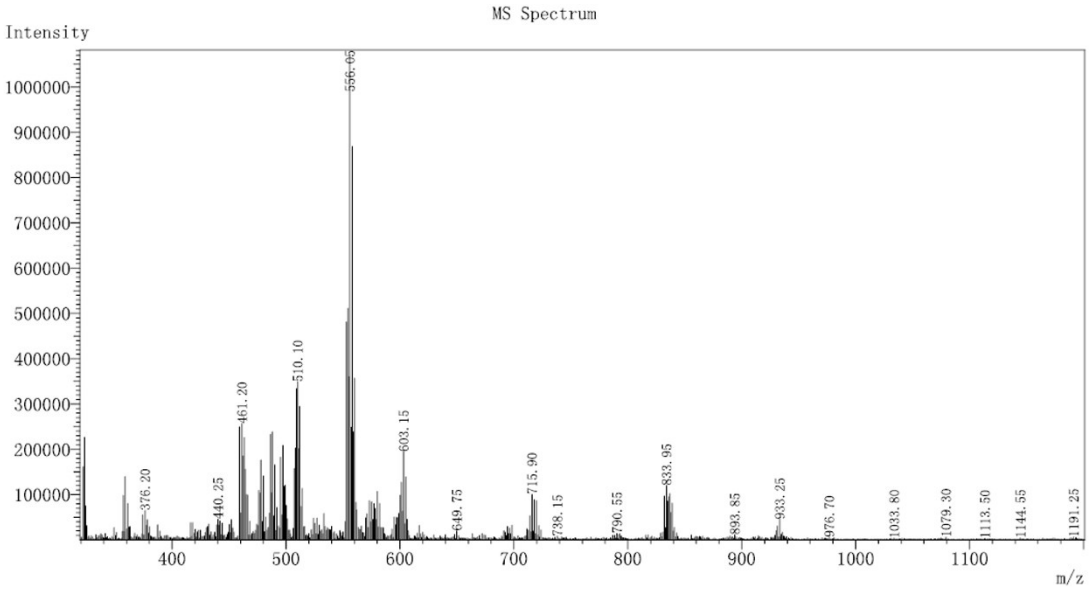


Figure S7. ESI-MS spectra of **Ln7** (2.0×10^{-5} M) in Tris-HCl buffer solution (containing 5% DMSO) for 0 h.

Figure S8. IR (KBr) spectra of **Ln1.**

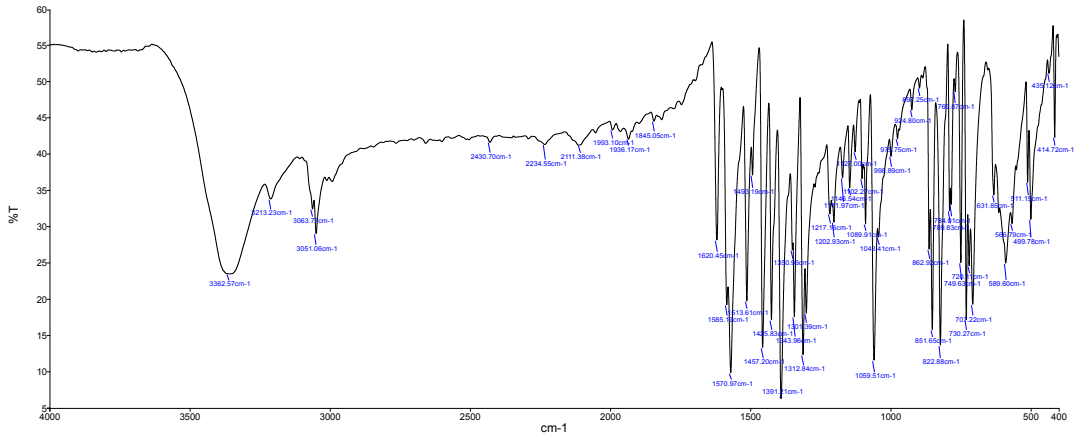


Figure S9. IR (KBr) spectra of **Ln2.**

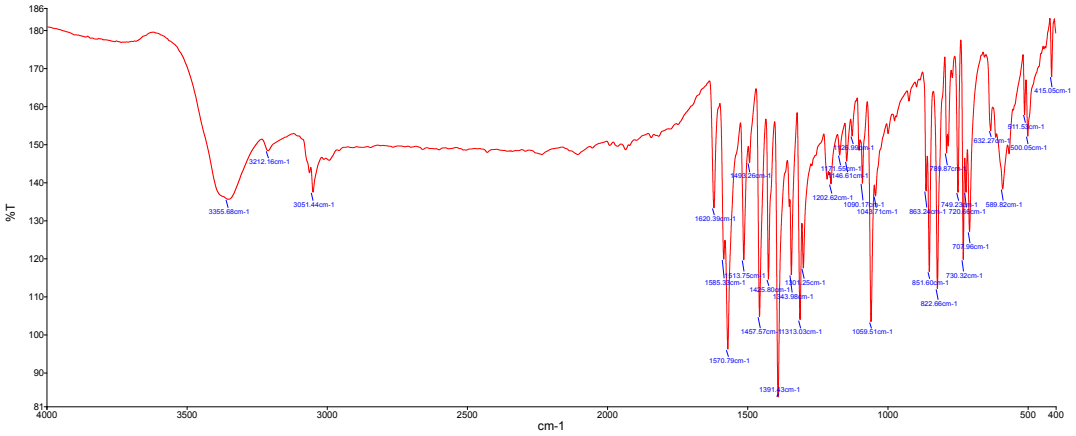


Figure S10. IR (KBr) spectra of **Ln3.**

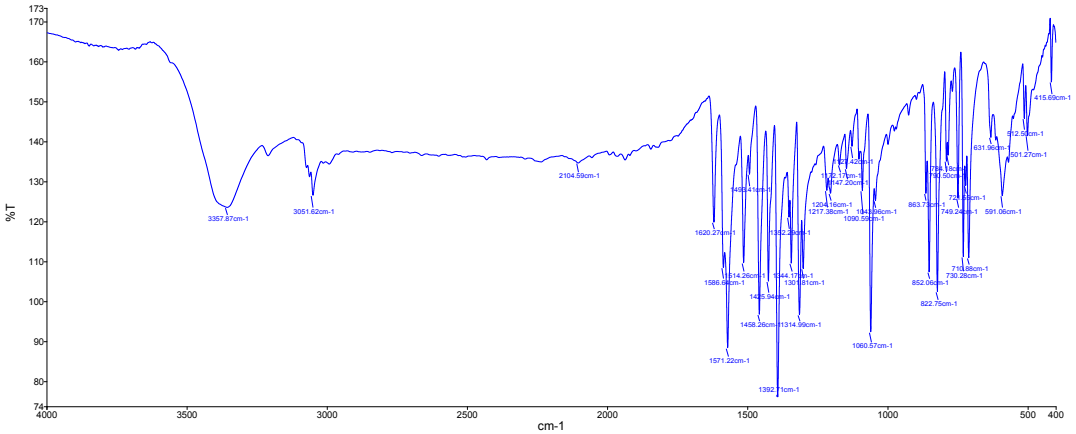


Figure S11. IR (KBr) spectra of **Ln4.**

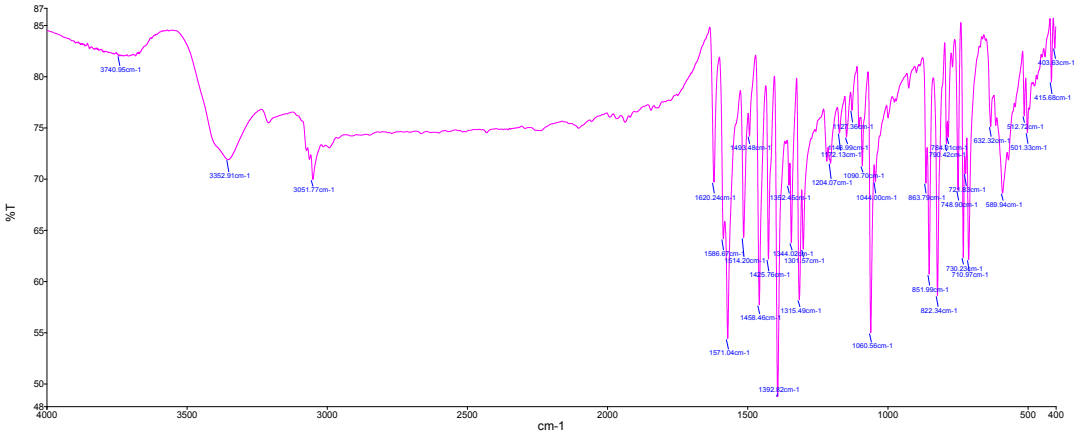


Figure S12. IR (KBr) spectra of **Ln5.**

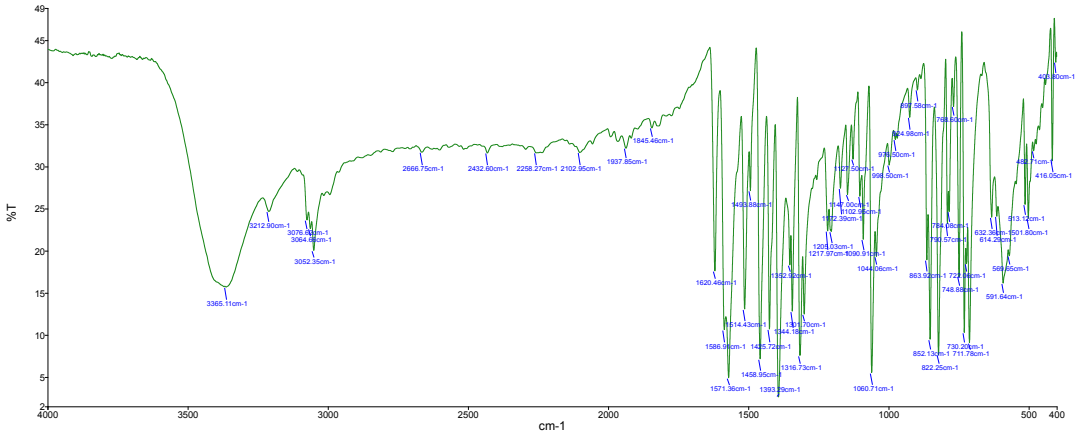


Figure S13. IR (KBr) spectra of **Ln6.**

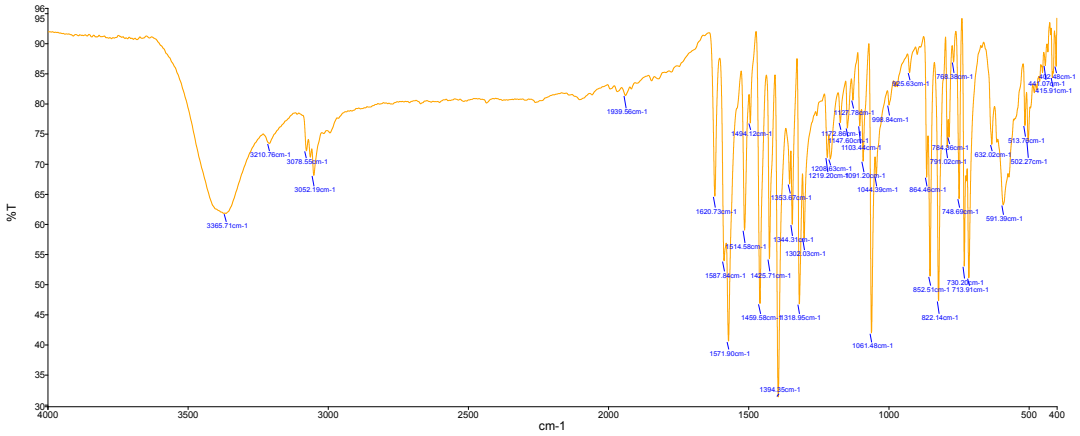


Figure S14. IR (KBr) spectra of **Ln7.**

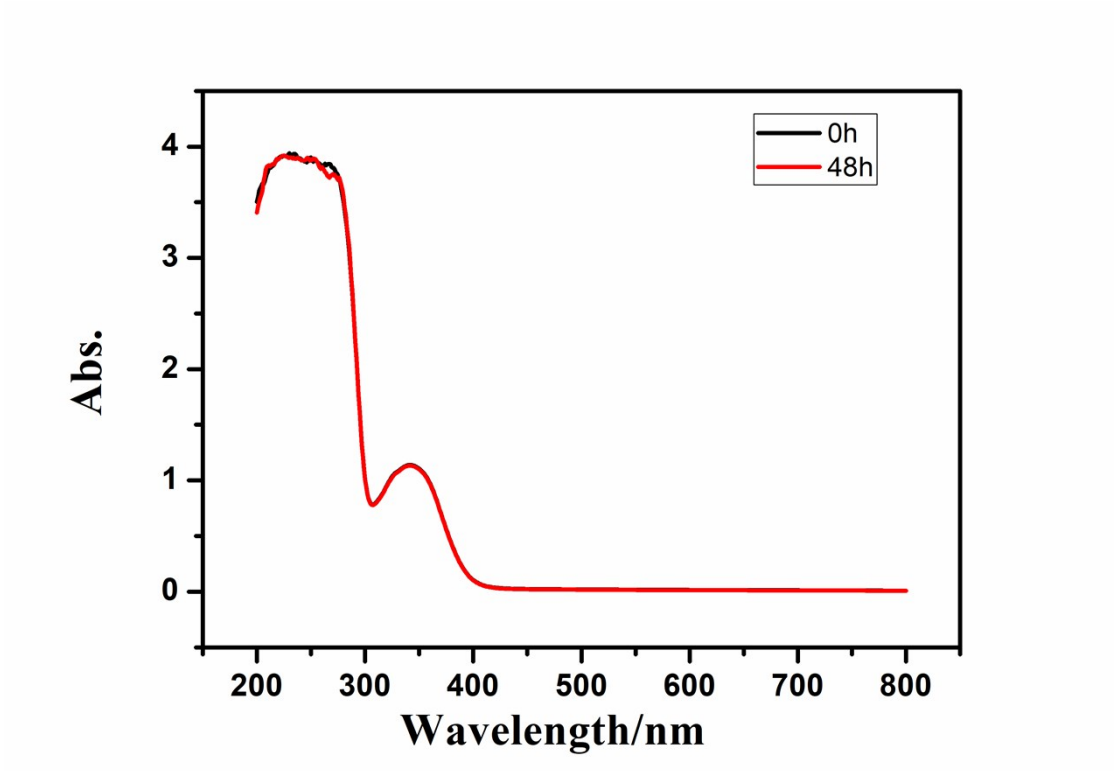


Figure S15. UV-Vis absorption spectra of **Ln1** (2.0×10^{-5} M) in Tris-HCl solution

in the time course 0 h and 48 h, respectively.

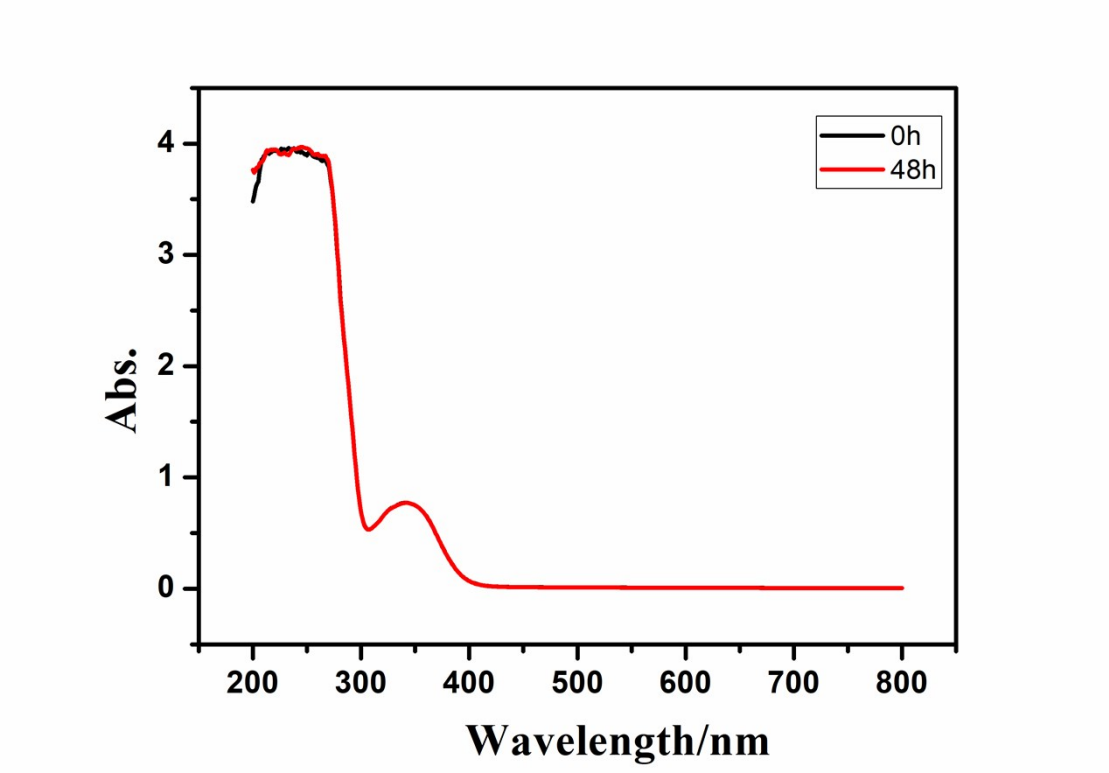


Figure S16. UV-Vis absorption spectra of **Ln2** (2.0×10^{-5} M) in Tris-HCl solution in the time course 0 h and 48 h, respectively.

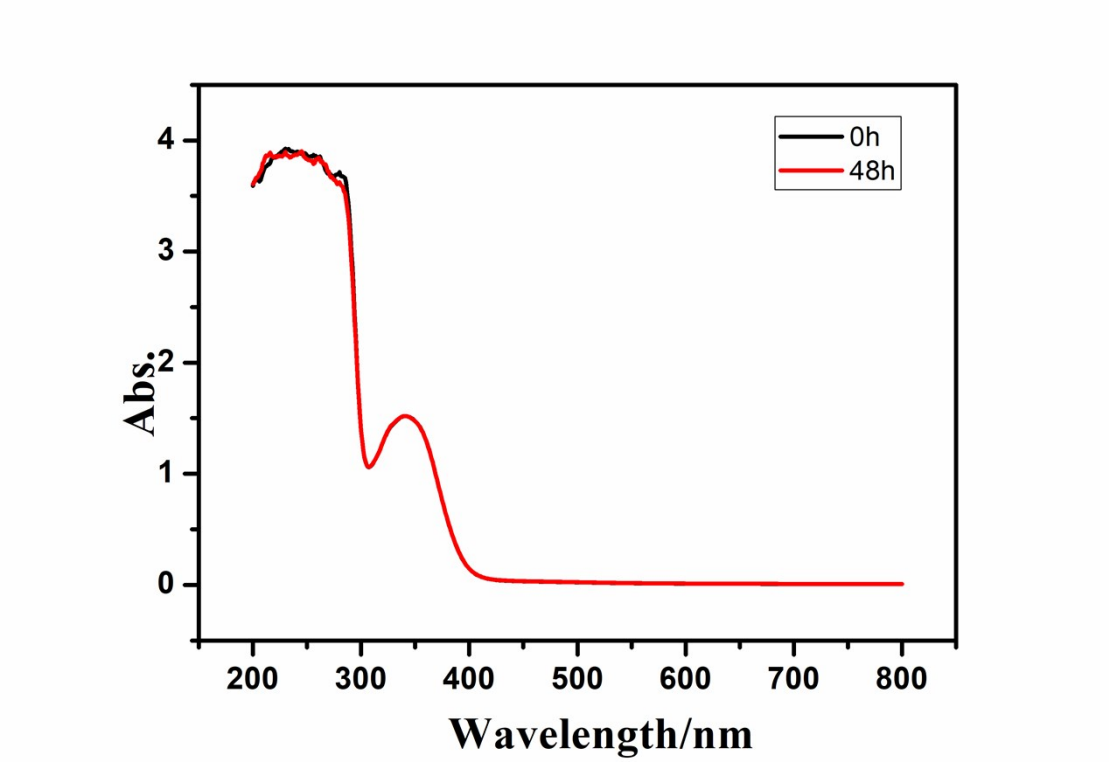


Figure S17. UV-Vis absorption spectra of **Ln3** (2.0×10^{-5} M) in Tris-HCl solution in

the time course 0 h and 48 h, respectively.

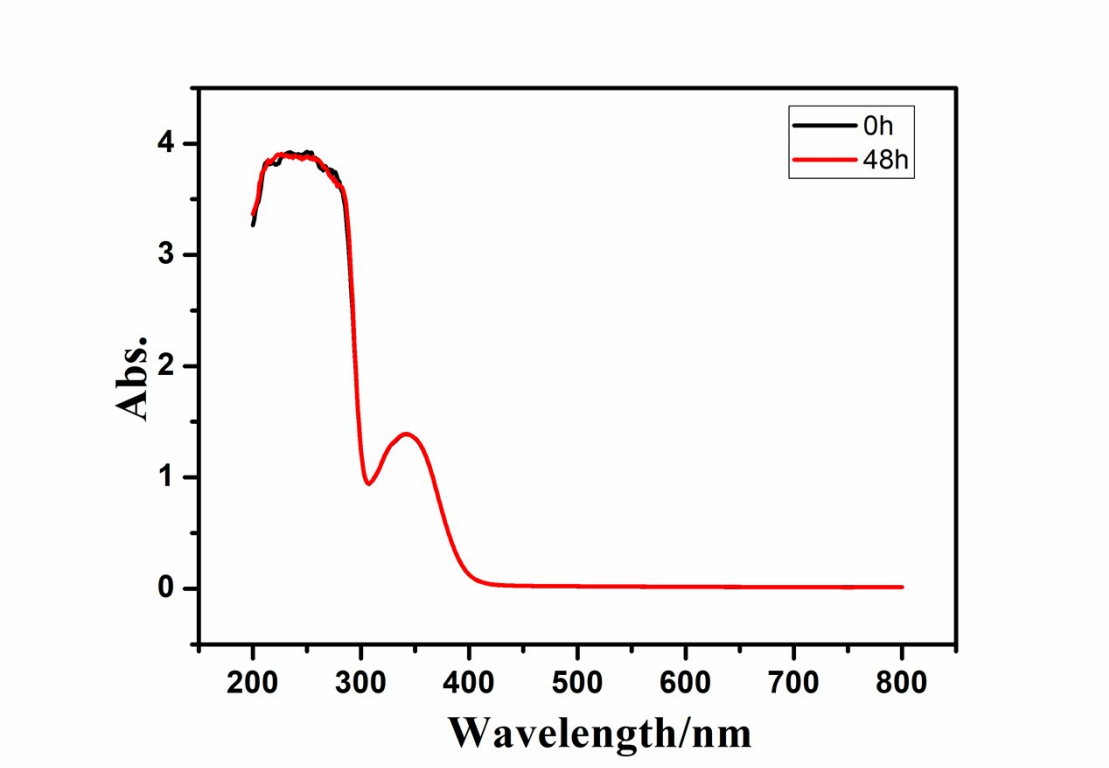


Figure S18. UV-Vis absorption spectra of **Ln4** (2.0×10^{-5} M) in Tris-HCl solution in the time course 0 h and 48 h, respectively.

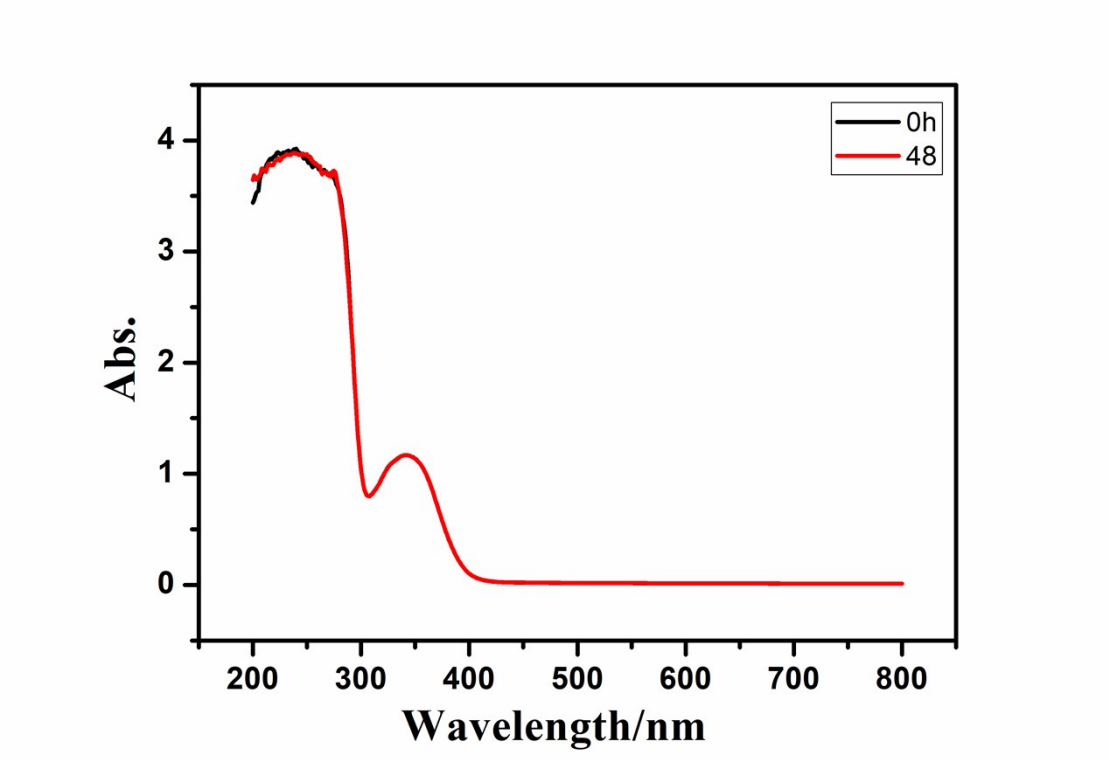


Figure S19. UV-Vis absorption spectra of **Ln5** (2.0×10^{-5} M) in Tris-HCl solution in

the time course 0 h and 48 h, respectively.

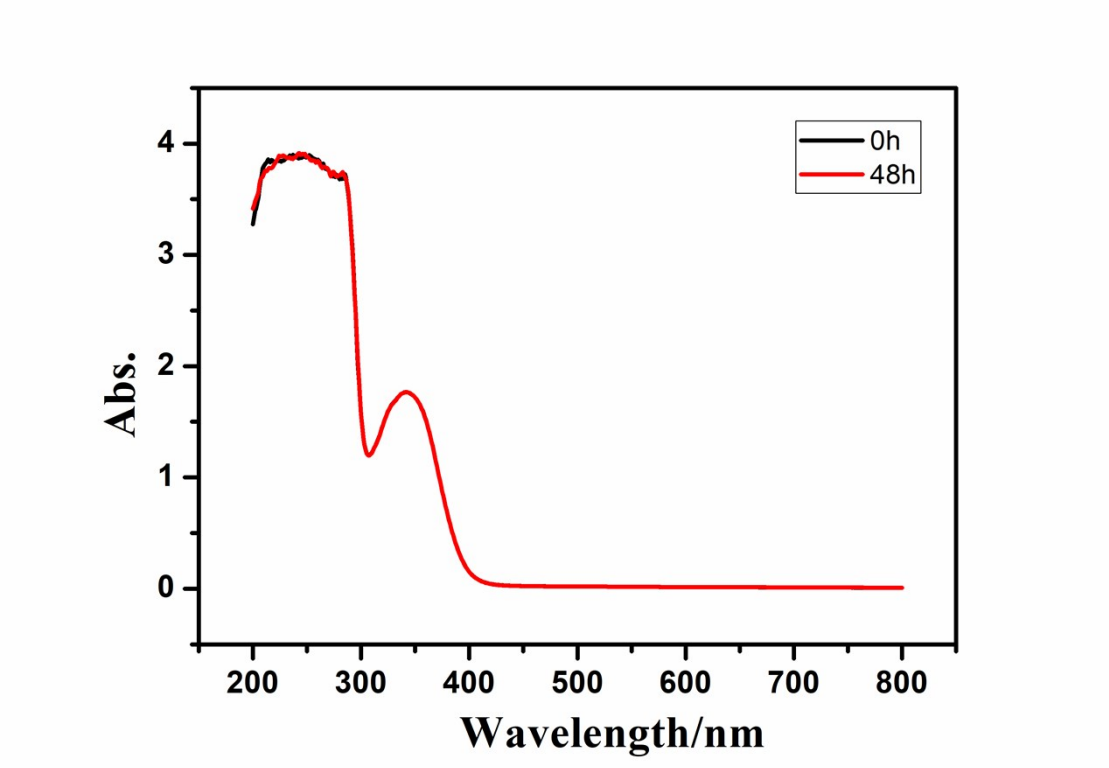


Figure S20. UV-Vis absorption spectra of **Ln6** (2.0×10^{-5} M) in Tris-HCl solution in the time course 0 h and 48 h, respectively.

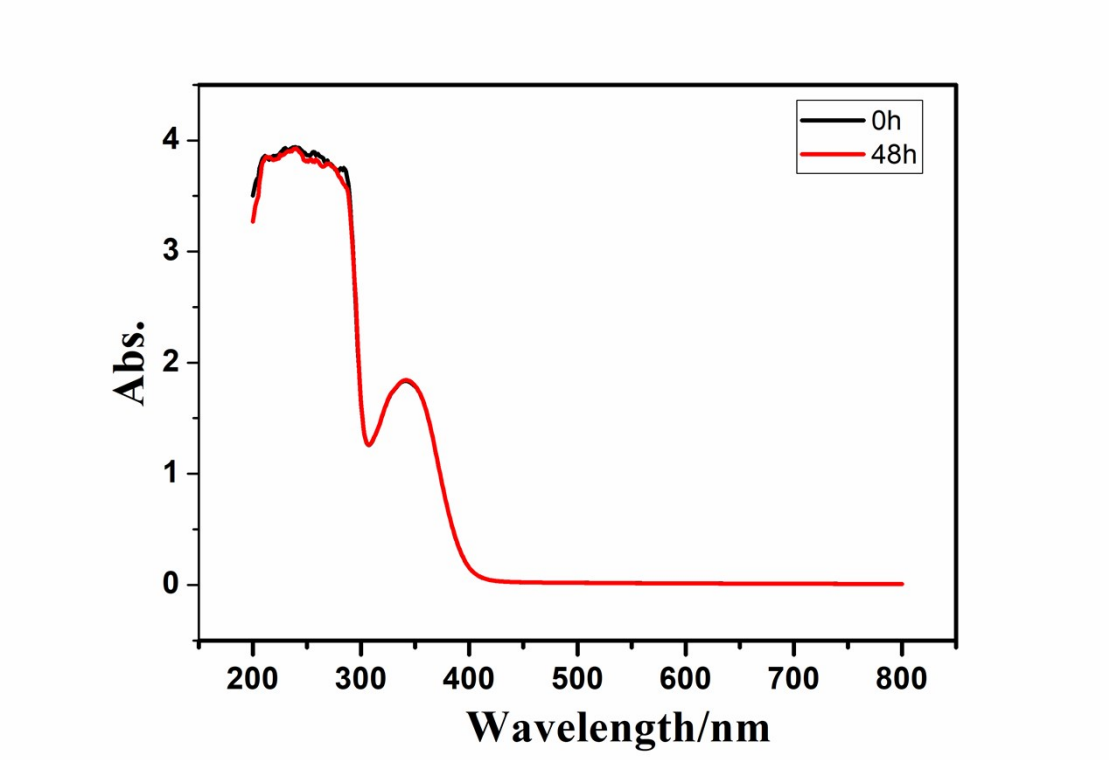
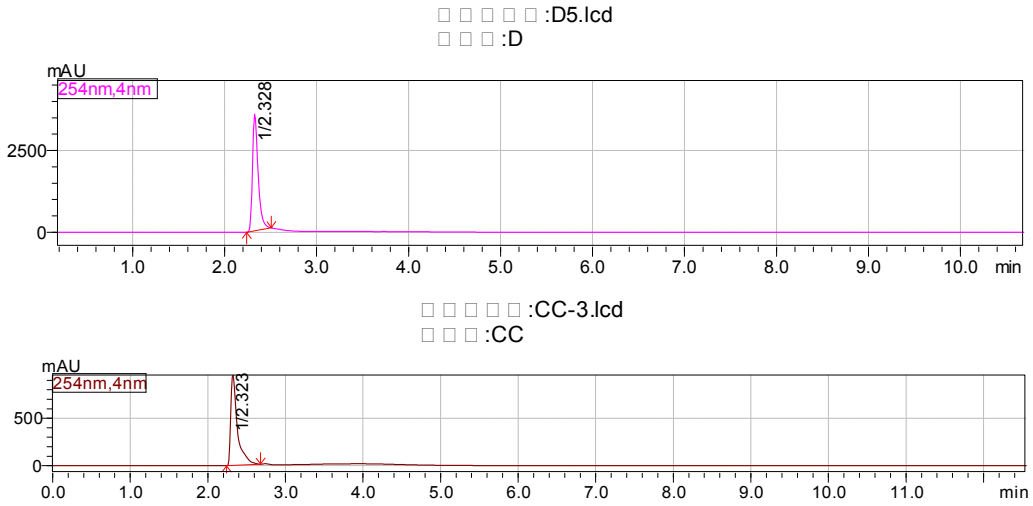
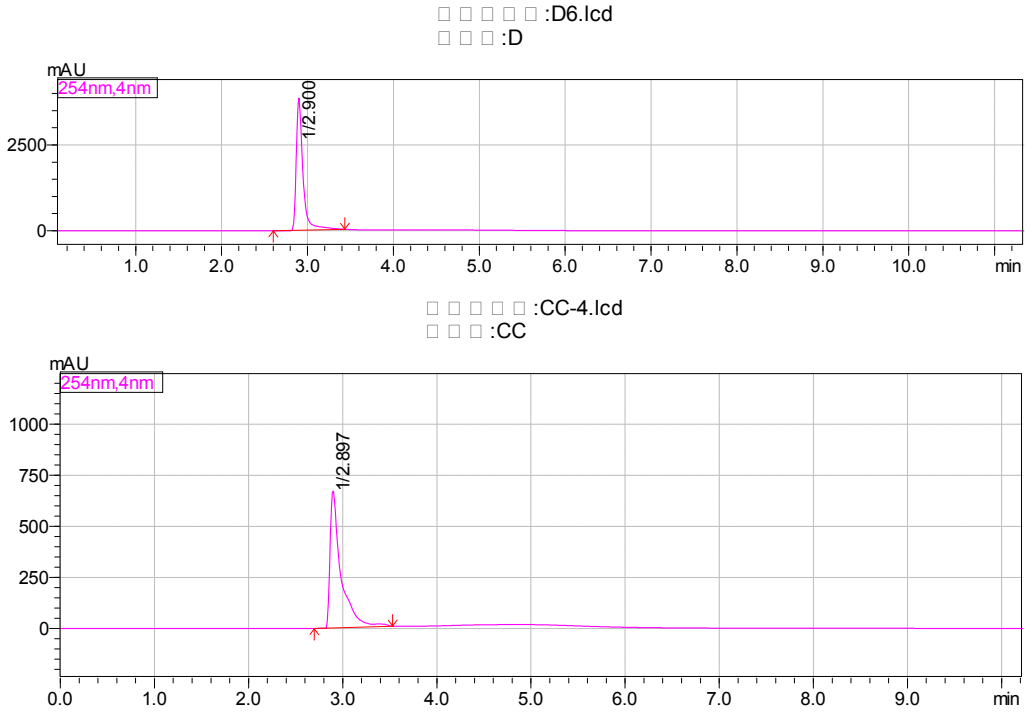


Figure S21. UV-Vis absorption spectra of **Ln7** (2.0×10^{-5} M) in Tris-HCl solution in

the time course 0 h and 48 h, respectively.



Figuer S22. HPLC spectra for **Ln1** (2.0×10^{-5} M) in TBS (Tris-HCl buffer solution, 10 mM, pH 7.35) solution with 0 h (up) and 48 h (down). Column: Inertsustain C18 column (LC-20AT, SPD-20A HPLC COLUMN, 150mm×5.0 μm I.D.). Column temperature: 40ºC. Mobile phase: methol/H_2O containing 0.01% TFA (99:1 methol/H_2O). Flow rate: 1.0 mL/min. Injection volume: 2.0×10^{-5} M.



Figuer S23. HPLC spectra for **Ln7** (2.0×10^{-5} M) in TBS (Tris-HCl buffer solution, 10 mM, pH 7.35) solution with 0 h (up) and 48 h (down). Column: Inertsustain

C18 column (LC-20AT, SPD-20A HPLC COLUMN, 150mm×5.0 μm I.D.). Column temperature: 40ºC. Mobile phase: methol/H_2O containing 0.01% TFA (99:1 methol/H_2O). Flow rate: 1.0 mL/min. Injection volume: 2.0×10^{-5} M.

Table S22. ESI-MS spectra of **Ln1-Ln7** (2.0×10^{-5} M) in Tris-HCl buffer solution (containing 5% DMSO) for 0 h

complexes	m/z (isotope of each complex)
Ln1	528.90; 530.15; 531.15; 532.15; 533.10; 534.00; 535.85; 537.05; 538.00; 539.20; 540.05; 541.30; 542.35; 544.20; 545.95
Ln2	533.00; 534.90; 536.15; 536.85; 539.00
Ln3	537.15; 538.15; 539.15; 540.05; 541.15; 542.05; 543.15; 543.95; 546.05; 547.65
Ln4	543.05; 544.10; 545.10; 546.05; 547.15; 548.05; 549.15; 550.05
Ln5	602.95; 604.95; 607.15; 609.00; 611.00; 613.00; 614.15; 615.00; 616.15; 616.85; 618.15; 619.10; 620.20; 621.10; 623.20; 625.20; 626.80; 629.20; 631.10; 633.15
Ln6	548.00; 549.05; 550.05; 551.15; 552.00; 553.15; 554.00; 555.15; 556.05; 558.10
Ln7	551.75; 552.75; 554.15; 555.15; 556.05; 557.15

Table S23. The tumor volume in treated and non-treated mice from the date of surgery to the study end point in the A549/DDP xenograft model.

	mg/kg	1day	3d			5d			7d		
		Tumor Volume (mm^3)	Tumor Volume (mm^3)	RTV	T/C%	Tumor Volume (mm^3)	RTV	T/C%	Tumor Volume (mm^3)	RTV	T/C%
Control	_	96.0±11.5	127.9±11.5	1.338±0.085	100.0	166.6±18.6	1.744±0.176	100.0	249.2±13.8	2.626±0.343	100.0
Ln1	2.0	96.4±10.4	127.6±9.3	1.328±0.060	99.7	156.4±10.2	1.630±0.082	93.5	207.4±19.9*	2.158±0.155*	83.2

	mg/kg	9d			11d			13d		
		Tumor Volume (mm^3)	RTV	T/C%	Tumor Volume (mm^3)	RTV	T/C%	Tumor Volume (mm^3)	RTV	T/C%
Control	_	396.2±39.2	4.176±0.684	100.0	604.3±73.3	6.335±0.805	100.0	808.3±113.9	8.500±8.344	100.0
Ln1	2.0	285.1±17.1*	2.980±0.297**	72.0	382.1±25.0*	3.996±0.440*	63.2	417.8±28.8*	4.367±0.461*	51.7

	mg/kg	15d		
		Tumor Volume (mm^3)	RTV	T/C%
Control	_	1027.9±64.1	10.798±1.097	100.0
Ln1	2.0	444.2±33.7*	4.643±0.525*	43.2

* p <0.01, p *vs* vehicle control

Table S24. Average body weight in treated and non-treated mice from the date of surgery to the study end point in the A549/DDP xenogfart model.

	mg/kg	1 d	3 d	5 d	7 d	9 d	11 d	13 d	15 d
Control	_	19.7±0.6	19.9±0.6	20.1±0.6	20.3±0.6	20.5±0.5	20.7±0.5	20.9±0.6	21.1±0.5
Ln1	2.0	19.8±0.3	20.0±0.3	20.1±0.3	20.3±0.3	20.5±0.3	20.7±0.4	20.8±0.4	21.0±0.4

* p <0.01, p *vs* vehicle control (5.0% v/v DMSO/ saline vehicle)

Table S25. In Vivo Anticancer Activity of **Ln1** (2.0 mg/kg) toward A549/DDP Tumor Xenograft.

	mg/kg	average tumor weight (mean ± SD, g)	inhibition of tumor growth (%)
Control	-	1.392±0.030	-
Ln1	2.0	0.606±0.042*	56.5

* p <0.01, p *vs* vehicle control (5.0% v/v DMSO/ saline vehicle).

1. Experimental section

1.1 Materials

The Tris, gel loading buffer, RNase A, 2-nitrobenzoic acid and propidium iodide (PI) were purchased from Sigma. The antibody of p62, Beclin1 and LC3 were purchased from Abcam. The mRFP-eGFP-LC3 fragment was purchased from Jiangsu KeyGEN BioTECH Corp., Ltd (China). The A549/DDP tumor cells and human HL-7702 normal cells obtained from the Shanghai Institute for Biological Science (China).

1.2 Instruments

Elemental analyses (C, H and N) were carried out on a PerkinElmer series II CHNS/O 2400 elemental analyzer. ESI-MS spectra was performed on Thermofisher Scientific Exactive LC-MS spectrometer (Thermal Elctronic, USA). The MTT assay was performed on M1000 microplate reader (Tecan Trading Co. Ltd., Shanghai, China). Apoptosis assay and the cellular localization behavior analysis were recorded on confocal microscopy (Olympus FV300, Japan).

1.3 Cell Culture

The cell culture was maintained in RPMI-1640 medium supplemented with 10.0% fetal bovine serum (FBS), 100.0 U/mL penicillin, and 100.0 μg/mL streptomycin in 25.0 cm^2 culture flasks at 37 °C in a humidified atmosphere with 5% CO_2. All the cells to be tested in the following assays had a passage number of 5.0.

1.4 MTT assays

The cells were seeded in 96 well plates at the density of 8000 cells per well for 24 h, then incubated with different concentrations of $SmCl_3·6H_2O$, $EuCl_3·6H_2O$, $GdCl_3·6H_2O$, $DyCl_3·6H_2O$, $HoCl_3·6H_2O$, $ErCl_3·6H_2O$, $YbCl_3·6H_2O$, NQ, phen, the lanthanide(III) complexes **Ln1**–**Ln7** and the clinically used cisplatin for 24.0 h, and the cell medium was discarded and MTT (1.0 mg/mL) was added. 4.0 h later, MTT solution was removed and DMSO was added. And obtained the results by a M1000 microplate reader (Tecan Trading Co. Ltd., Shanghai, China) at 570 nm. [1-4]

1.5 Apoptotosis assay

Annexin V-FITC staining of the membranes was performed by using the Annexin-V APC and SYTO X. The A549/DDP cells were incubated with the Ln(III) complexes **Ln1** (25nM) and **Ln7** (97nM) for 24.0 h, and then the cells were stained with Annexin-V APC (λex= 635 nm, λem = 660 nm) and SYTO X ((λex= 502 nm, λem = 525 nm)) double staining, and analyzed by flow cytometry

1.6 Fluorescence imaging

Immunohistochemistry and fluorescence imaging were performed as previously described by Lee [2].

1.7 Western Blot

The A549/DDP cells were incubated with the Ln(III) complexes **Ln1** (25nM) and **Ln7** (97nM) for 24.0 h, and then the cells harvested from each well of the culture plates were lysed in 150 μL of extraction buffer consisting of 149 μL of RIPA lysis buffer and 1 μL of PMSF (100 mM). The suspension was centrifuged at 10 000 rpm at 4 °C for 10 min, and the supernatant (10μL for each sample) was loaded onto 10% polyacrylamide gel and then transferred to a microporous polyvinylidene difluoride (PVDF)membrane. Western blotting was performed using anti-p62, Beclin1 and LC3 antibody, or anti-β-actin primary antibody and horseradish-peroxidase-conjugated anti-mouse or anti-rabbit secondary antibody. The protein bands were visualized using chemiluminescence substrate.

1.8 Anti-cancer activity toward A549/DDP *in vivo*

The A549/DDP cells were harvested and injected subcutaneously into the right flank of nude mice with 5×10^6 cells in 200 μL of serum-free medium. When the xenograft tumor growth to the volume about 1000 mm^3, the mice were killed and the tumor tissue were cut into about 1.5 mm^3 small pieces, and then transplanted into the right flank of female nude mice, When tumors reach a volume of 80-190 mm^3 on all mice, the mice were randomized into vehicle control and treatment groups (n=6/group), received the following treatments: (a) vehicle control, 5.0% v/v DMSO/ saline vehicle, (b) **Ln1** at dose 2.0 mg/kg every two day (5.0% v/v DMSO/saline) via percutaneous injection every 2 days (q2d). The tumor volumes were determined every three days by measuring length (*l*) and width (*w*) and calculating volume, tumor volume and inhibition of tumor growth were calculated using formulas 1−3:[1-4]

Tumor volume: $V = (w^2\times l)/2$ (1)

The tumor relative increment rate: $T/C\ (\%) = T_{RTV}/C_{RTV}\times100\%$ (2)

inhibition of tumor growth: $IR(\%) = (W_c - W_t)/W_c\times100\%$ (3)

Where w and l mean the shorter and the longer diameter of the tumor respectively; T_{RTV} and C_{RTV} was the RTV of treated group and control group respectively. (RTV: relative tumor volume, RTV= V_t /V_0); W_t and W_c mean the average tumor weight of complex-treated and vehicle controlled group respectively.

In addition, the A549/DDP xenograft mouse models were purchased from Changzhou cavens experimental animal Co., Ltd (Jiangsu, China, approval No. SCXK 2016-0010). The animal procedures were approved by Changzhou cavens experimental animal Co., Ltd (Jiangsu, China, approval No. 2017-0040). And all of the experimental procedures were carried out in accordance with the NIH Guidelines for the Care and Use of Laboratory Animals. Animal experiments were approved by Changzhou cavens experimental animal Co., Ltd ((Jiangsu, China).

1.9 Statistical Analysis

The experiments have been repeated from three to five times, and the results obtained are presented as means ± standard deviation (SD). Significant changes were assesses by using Student's *t* test for unpaired data, and p values of <0.05 were considered significant.

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