Supplementary information

ESI. S1. Synthesis of complexes

The compounds cis-[Ru(dmbpy)$_2$Cl$_2$].2H$_2$O, cis-[Ru(bpy)$_2$Cl$_2$].2H$_2$O, cis[Ru(phen)$_2$Cl$_2$].2H$_2$O were synthesized according to literature methods [1].

Synthesis of [Ru(bpy)$_2$(DPCO)](ClO$_4$)=[Ru(LH4). 1mmol of [Ru(bpy)$_2$Cl]$_2$ and 1 mmol of DPC ligand was solved in 5 mL of DMF and heated at 120 ºC for 10h. To facilitate deprotonation of DPC to produce DPCO, 0.2 mL of NEt$_3$ was also added to mixture. After that, the solution was treated with saturated aqueous solution of NaClO$_4$ and gave a dark violet precipitate and washed several times with water to remove traces of salts. The crude product was purified by column chromatography on alumina with CH$_3$CN-toluene (1/1, v/v) as an eluent. The mainly violet band was collected. The solvent was removed under reduced pressure and crystals were obtained. CHN analysis, Calculated (%): C, 52.633; H, 3.754; N, 14.882. Found (%): C, 52.626; H, 3.761; N, 14.877. ^{1}HNMR (400 MHz, D$_6$-DMSO): 9.55 (s, 1H), 8.78 (d, 4H), 8.59 (d, 4H), 7.57 (t, 4H), 7.36 (t, 2H), 7.23-7.25 (m, 4H), 7.06-7.15 (m, 7H), 6.81 (t, 1H). ESI-MS Cal. ESI-MS Cal. for [C$_{33}$H$_{28}$N$_8$ORu]$^+$ 653.85, found 653.78.
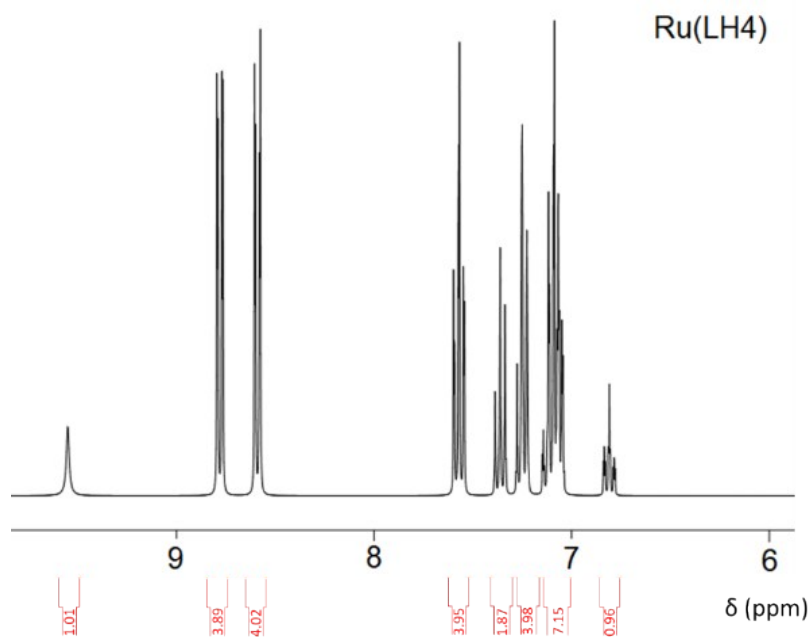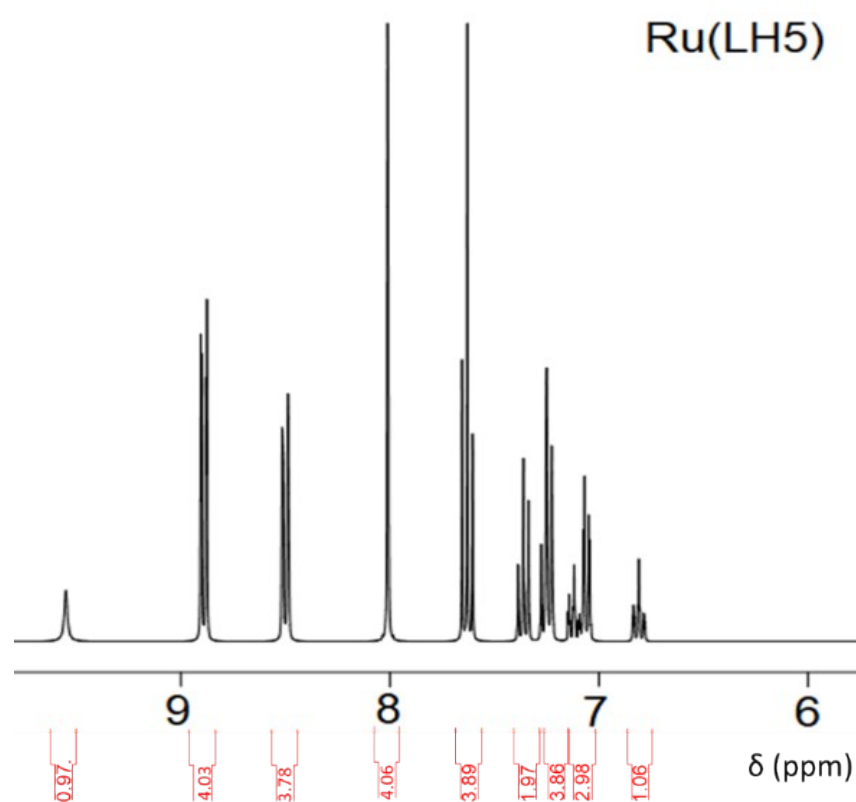

ESI. Fig. S1.Aromatic region of ^{1}HNMR of [Ru(LH4)] in DMSO-d6 solvent at room temperature.
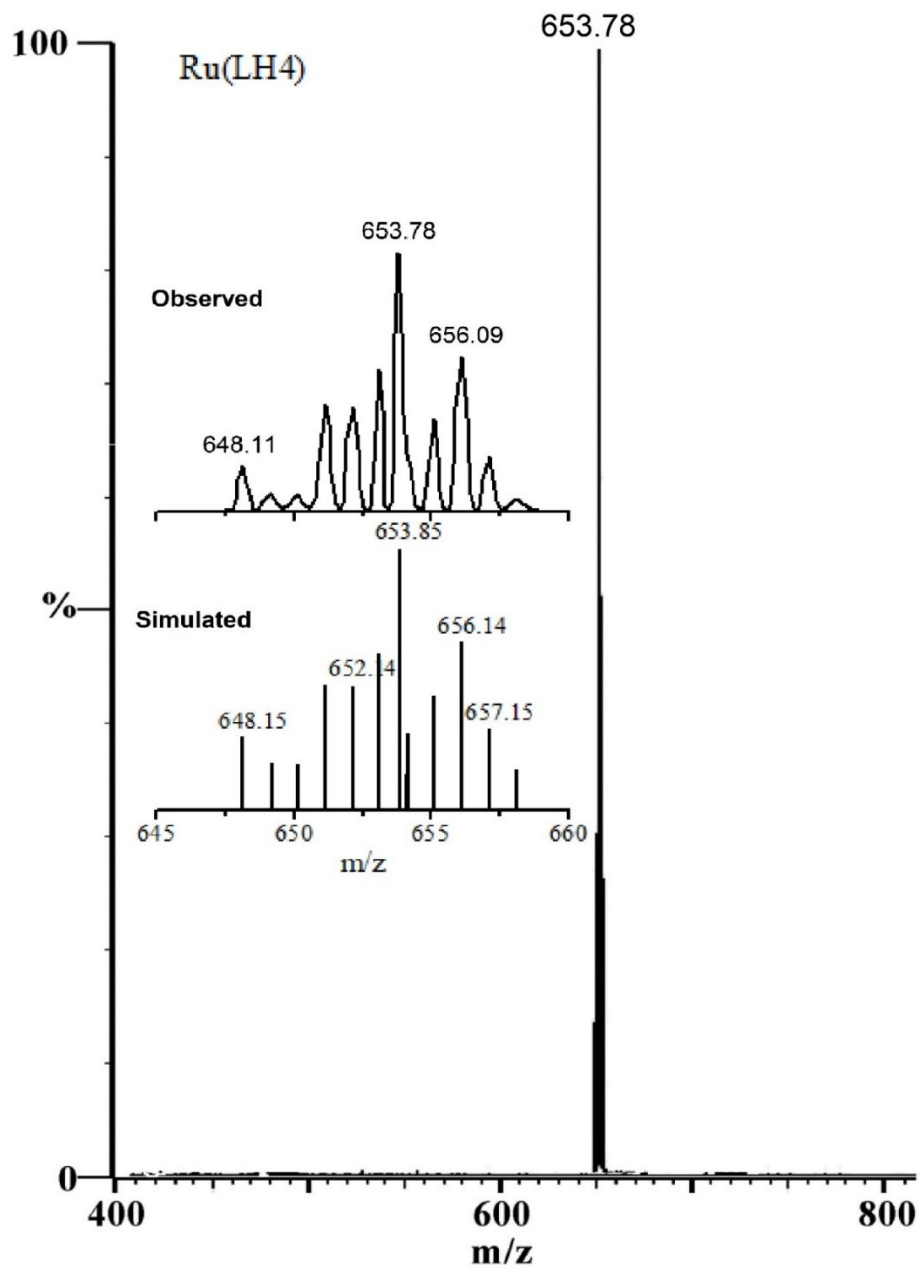
ESI. Fig. S2. ESI-MS spectra of [Ru(LH4)].

Synthesis of [Ru(phen)₂(DPCO)](ClO₄)=[Ru(LH5)]. The procedure for synthesis of Ru(LH5) is similar to Ru(LH4) except that for preparation of precursor, 2,2-bipyridine ligand was replaced by 1,10-phenanthroline. CHN analysis, Calculated (%): C, 55.54; H, 3.40; N, 14.00. Found (%): C, 55.536; H, 3.39; N, 14.01. ^{1}HNMR (400 MHz, D$_6$-DMSO): 9.55 (s, 1H), 8.88 (d, 4H), 8.55 (d, 4H), 7.98 (s, 4H), 7.63 (t, 4H), 7.36 (t, 2H), 7.22-7.25 (m, 4H), 7.06-7.12 (m, 3H), 6.83 (t, 1H). ESI-MS Cal. for $[C_{37}H_{28}N_8ORu]^+$ 701.80, found.701.75.

ESI. Fig. S3.Aromatic region of ^{1}HNMR of [Ru(LH5)] in DMSO-d6 solvent at room temperature.
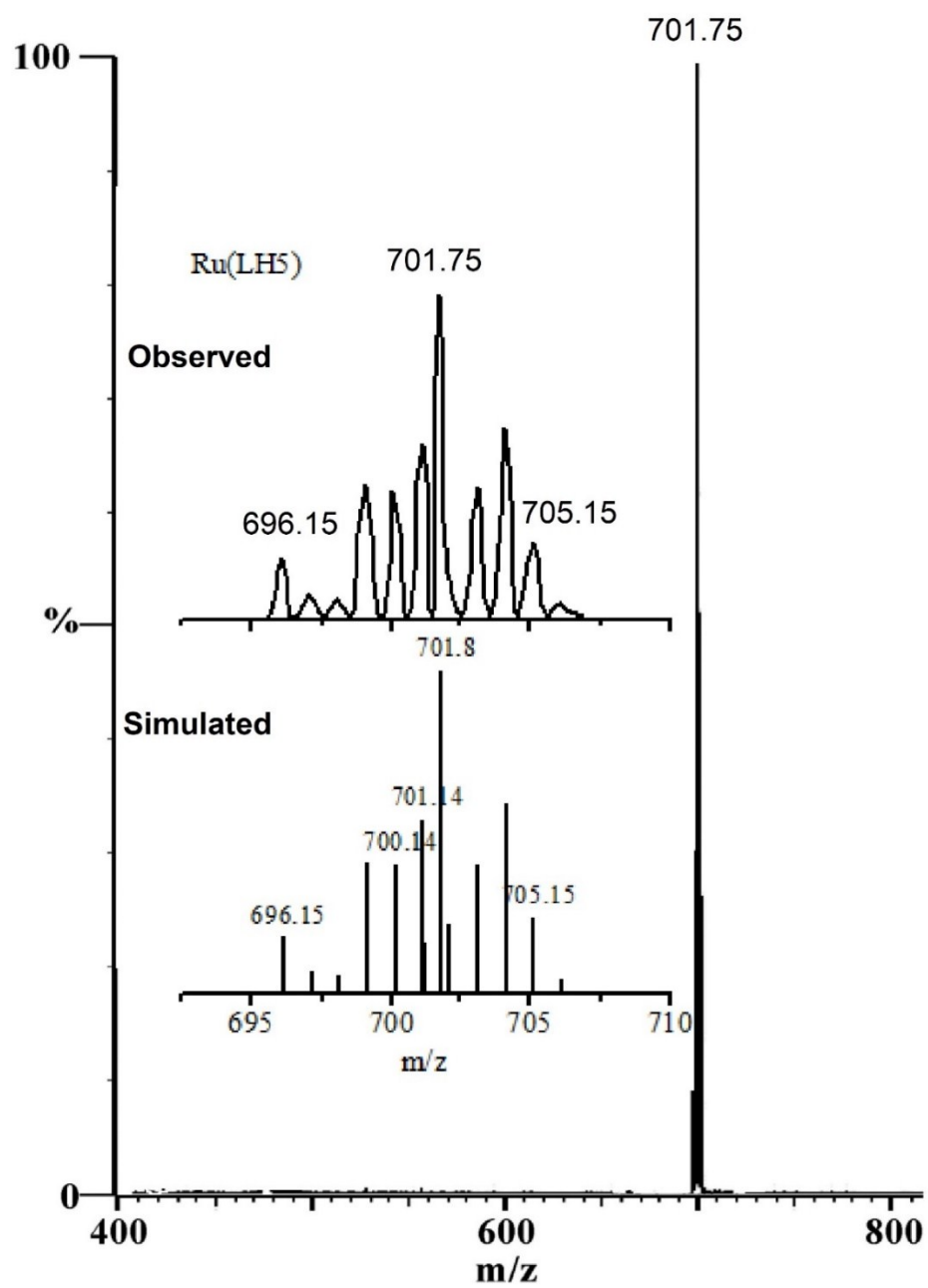
ESI. Fig. S4. ESI-MS of [Ru(LH5)].

Synthesis of [Ru(dmbpy)₂(DPCO)]=[Ru(LH6). Ru(LH6) was synthesized by same procedure for Ru(LH4) except that the 2,2-bipyridine was replaced by 4,4 dimethyl-2,2 bipyridine. CHN analysis, Calculated (%): C, 54.98; H, 4.36; N, 13.86. Found (%):C, 54.92; H, 4.35; N, 13.84.^{1}HNMR (400 MHz, D₆-DMSO): 9.56 (s, 1H), 8.80 (s, 4H), 8.60 (d, 4H), 7.63 (t, 2H), 7.50 (t, 2H), 7.33 (t, 1H), 7.19-7.25 (m, 6H), 7.02 (d, 2H), 6.79 (t, 1H), 2.43 (CH₃ of dmbpy, overlap with solvent peak). ESI-MS Cal. for [C₃₇H₃₆N₈ORu]⁺ 709.35, found 709.29.
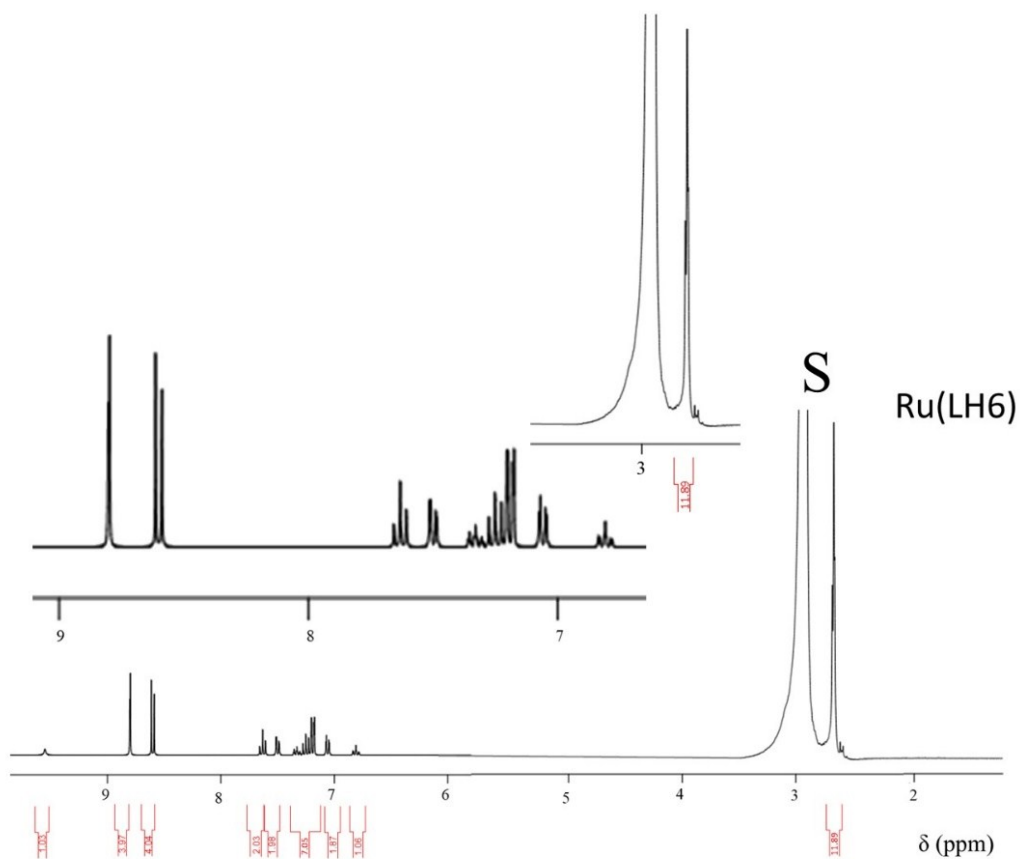
ESI. Fig. S5. ^{1}HNMR of [Ru(LH6)] in DMSO-d6 solvent at room temperature.
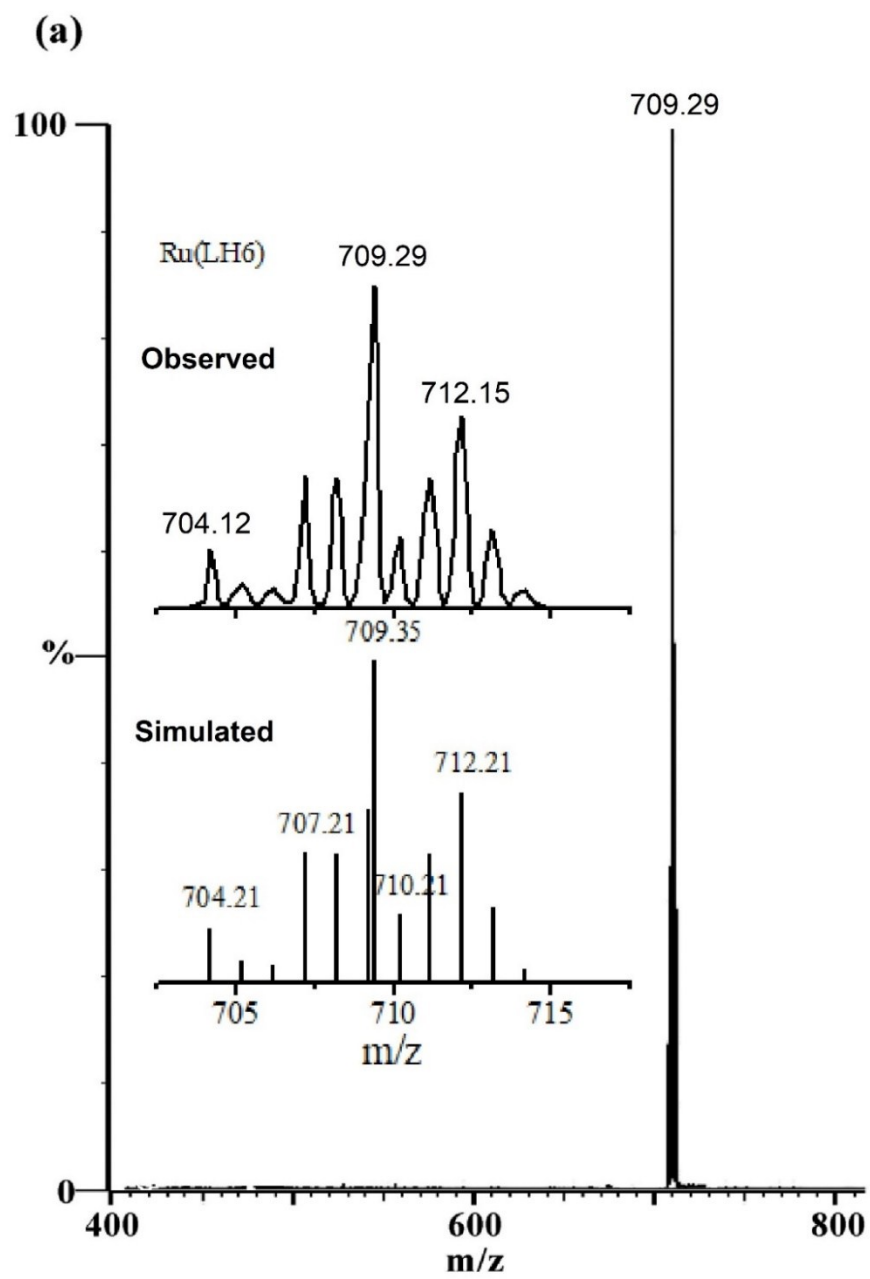
ESI. Fig. S6. ESI-MS of [Ru(LH6)].

S2. Equipment

All materials and solvents were purchased from Sigma-Aldrich and Merck without any future purification. Elemental analyses of carbon, hydrogen, and nitrogen were carried out with an Elementar Vario CHN analyzer. IR spectroscopy studies were performed on a FT-IR spectrophotometer in the 400- 4000 cm^{-1} region (w, weak; b, broad; m, medium; s, strong). ^{1}H NMR spectra is recorded on a Bruker 250 MHz spectrometer (s, singlet; d, doublet; t, triplet; m, multiplet; dd, double doublet). Analyses were performed. UV-vis absorption spectra in methanol solution were recorded on a 160 Shimadzu UV-vis spectrophotometer. Electroluminescence (EL) emissions spectra were recorded with an ocean optic USB2000spectrophotometer. Electrochemical measurements were employed in a SAMA500 electro analyzer using 10^{-3} molL^{-1} solution of CH$_3$CN at a various scan rate. The electrolytic cell consists of platinum disc as the working electrode, a platinum wire as the counter electrode, and Ag/AgCl as the reference electrode. The supporting electrolyte was 0.1 mol.L^{-1} tetrabutylammonium perchlorate (TBAP) in CH$_3$CN solutions.

Photoluminescence (PL) spectra of complexes in degassed solutions at 298 K and neat films were recorded using Varian-Cary Eclipse flourescence spectrophotometer and AvaSpec-125 spectrophotometer, respectively. The PLQY (PL quantum yields) were calculated against [Ru(bpy)$_3$]$^{2+}$ in degassed acetonitrile solution at 298 K as a standard ($\emptyset_{std} = 9.55$ % [2]) using the following equation:

$$\emptyset_{unk} = \emptyset_{std}.(\frac{I_{unk}/A_{unk}}{I_{std}/A_{std}}).(\frac{\eta_{unk}}{\eta_{std}})^2$$

In this equation, Φ_{unk} is phosphorescence quantum yields of complexes, I_{unk} and I_{std} are the integrated areas of the corrected PL spectra and standard, respectively, A_{unk} and A_{std} are the absorbances of the ruthenium complexes and the standard at the excitation wavelength ($\lambda_{exc}= 460$ nm), and η_{unk} and η_{std} are the indexes of refraction of the respective solvents (taken to be equal to the neat solvents in both cases).

S3. Fabrication and measurements of LEC devices

Indium tin oxide (ITO) coated glass with a sheet resistance of 15-18 Ω/ was used as anode. After being sufficiently cleaned with isopropanol, ethanol and deionized water, it was dried in the oven at 90 °C for 4 h. The devices were prepared by spin-coating a thin layer of each complexes from a 4% (w/v) acetonitrile solution at room temperature, on top of an ITO glass substrate. All solution and film preparation were carried out under ambient conditions. The thicknesses of the films were

~ 85 nm, measured with profilometry. After spin coating, the thin films were baked at 75 °C in inert atmosphere for 12 hours to remove the solvent residue (acetonitrile). A Ga: In (75.5:24.5 wt %, mp 15.7 °C) eutectic cathode (ca. 3.5 mm diameter) was printed on the films at room temperature by using a special syringe and then connected via a thin copper wire inserted into the Ga:In contact. Finally, it was sealed with epoxy cement. All EL measurement was carried out in air atmosphere. The electrical and emission characteristics of LEC devices were measured using a SAMA500 electroanalayzer system and an AvaSpec-125 spectrophotometer and a Photo Research PR-650 spectroradiometer.

Density functional theory (DFT) calculations were performed on the optimized structures in order to simulate the absorption spectra, using the B3LYP exchange-correlation functional within the Amsterdam density functional program package (ADF2014).
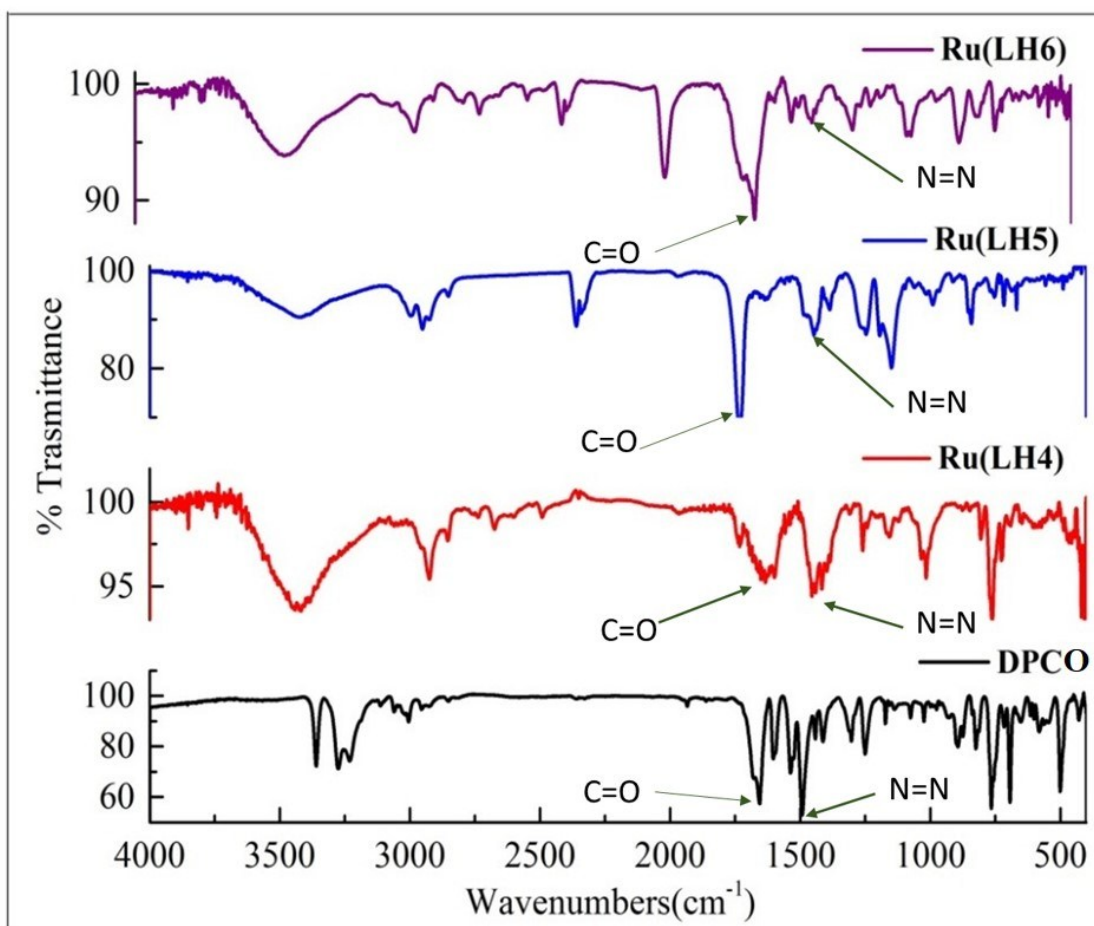
ESI. Fig. S7. The FT-IR spectra of DPCO and Ru(LH4-6) complexes with KBr disk.
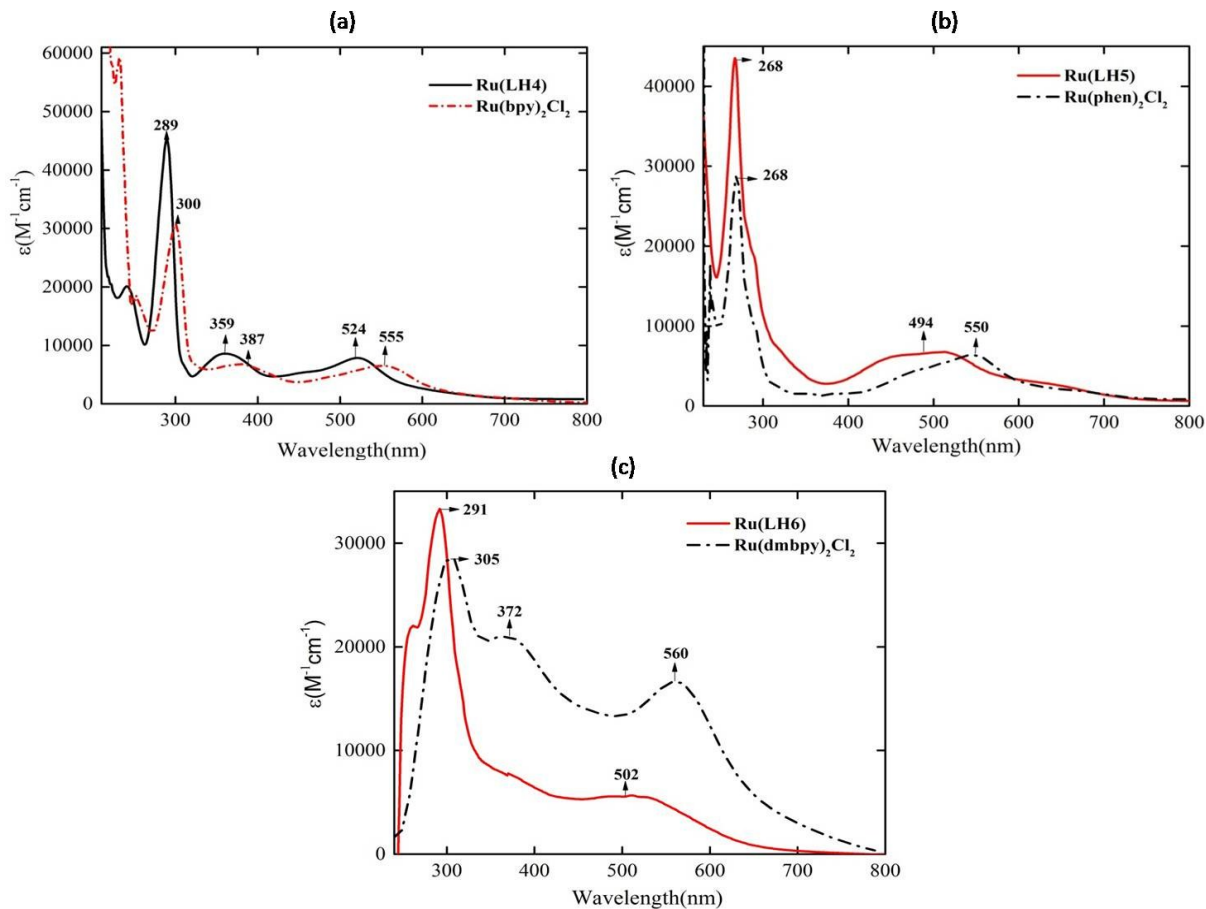
ESI. Fig. S8. The UV-Vis spectra of precursor and products of Ru(LH4-6) in methanol.
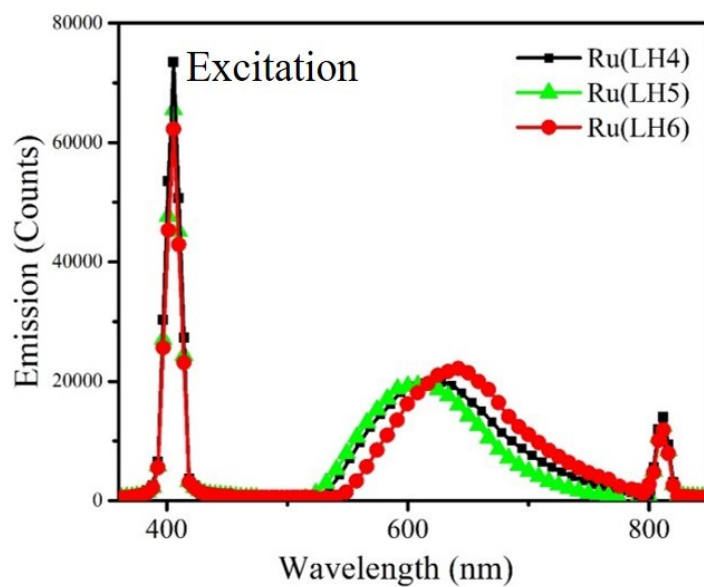
ESI. Fig. S9. The emission spectra of Ru(LH4-6) in methanol. The excitation wavelengths of first and second harmonics of laser source at 405 nm and 810 nm are also shown, respectively.

Ru(LH 4)   **Ru (LH 5)**   **Ru (LH 6)**
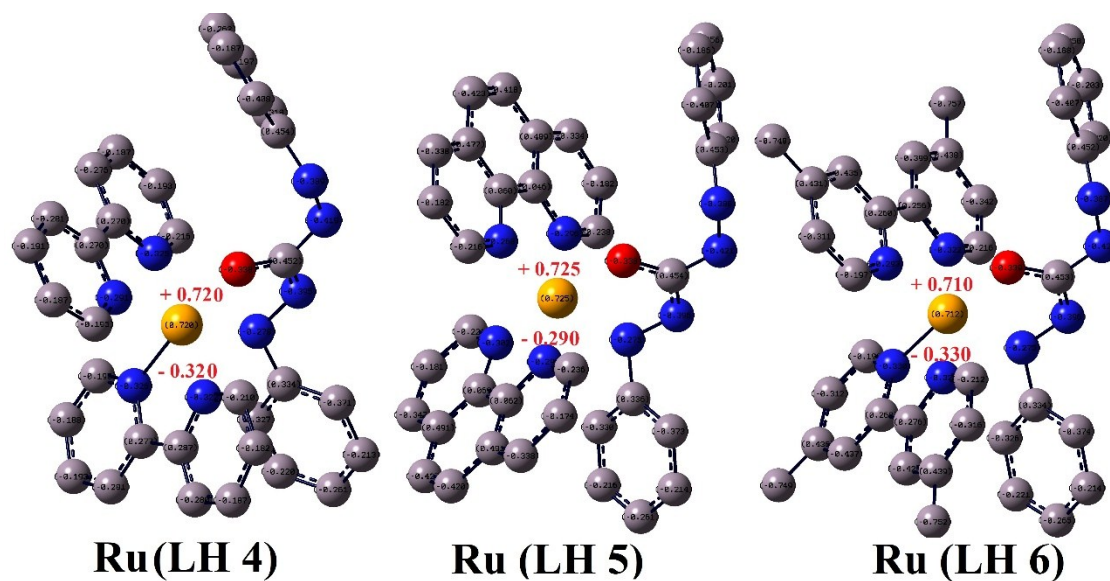
ESI. Figure S10. Charge distribution values of Ru(LH4-6) complexes obtained from the DFT method through LANL2DZ/6-31G* basis set.
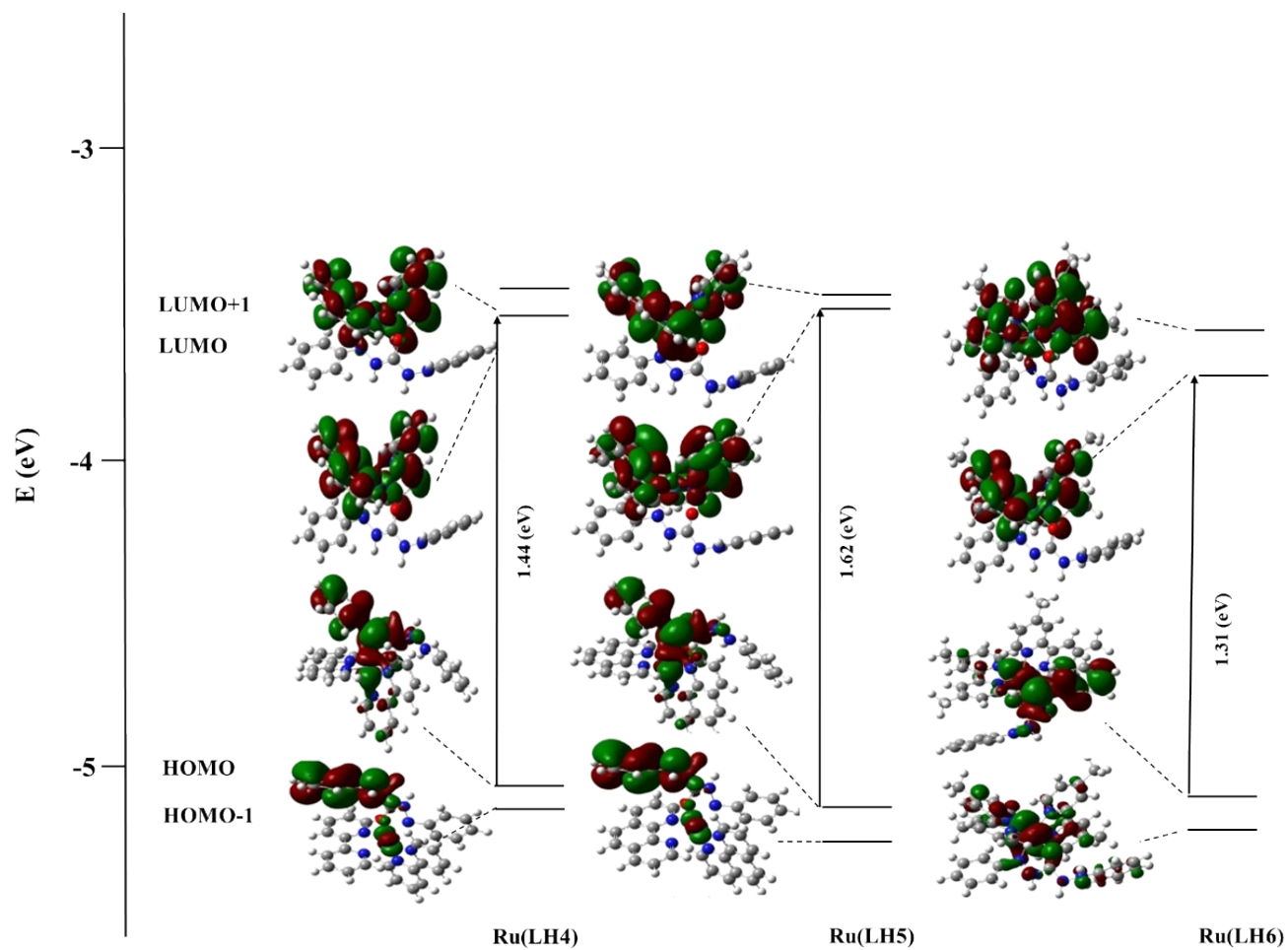
ESI. Figure S11. Isosurfaces (Isodensity contour= 0.03) for HOMO and LUMO of complexes obtained from the DFT method through LANL2DZ/6-31G* basis set.
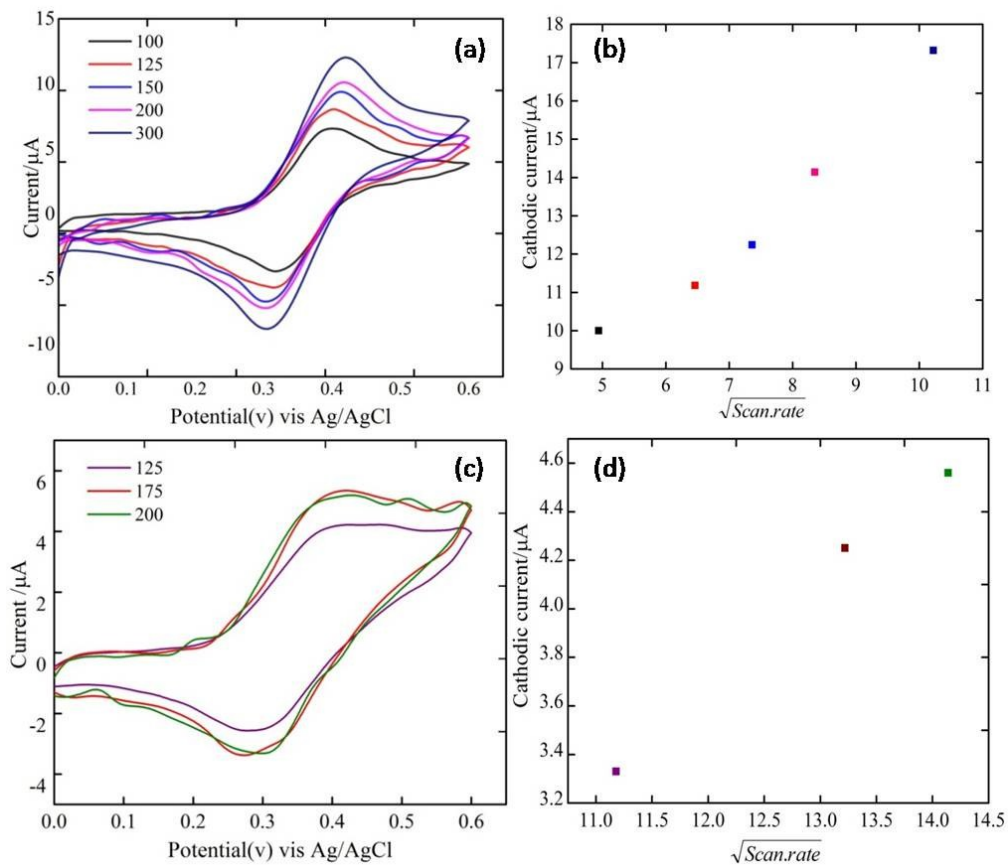
ESI. Fig. S12. Figures (a) and (c) show the varied scan rates for Ru(LH4) and Ru(LH5), respectively. Figures (b) and (d) show Survey of diffusion current of Ru(LH4) and Ru(LH5), respectively. All experiments were done under a dry N_2 atmosphere at 298 K in a three-electrode configuration by using a Pt-disk working electrode and a Pt-wire auxiliary electrode. The potentials are referenced to a saturated Ag/AgCl reference electrode. The supporting electrolyte was 0.1 M tetrabutylammonium perchlorate (TBAP)in methanol solutions.
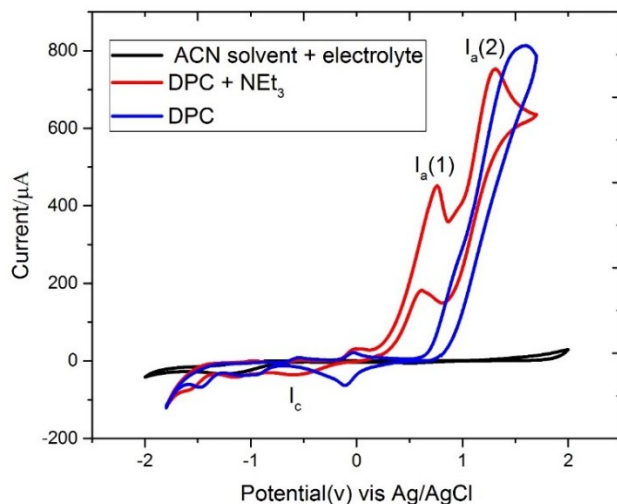
ESI. Fig. S13. The CV of DPC, DPC with NEt$_3$ and background (ACN +electrolyte).The electrolytic cell consists of platinum disc as the working electrode, a platinum wire as the counter electrode, and Ag/AgCl as the reference electrode. The supporting electrolyte was 0.1 molL-1 tetrabutylammonium perchlorate (TBAP) in acetonitrile solutions .
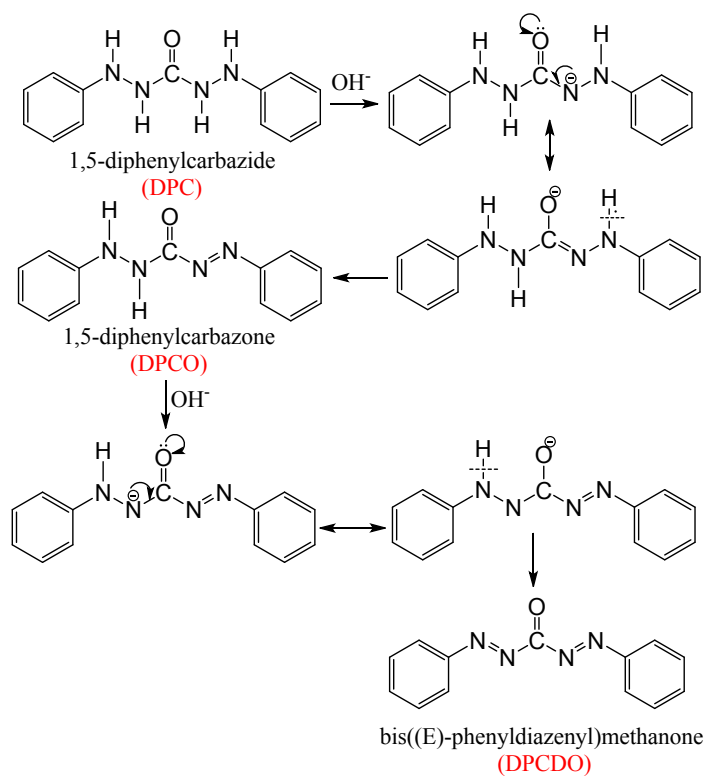
Scheme S1. Chemical structures commonly proposed for DPC, DPCO and DPDO undergoin oxidation in alkalin medium. 1,5-diphenylcarbazide (DPCO), 1,5-diphenylcarbazone (DPCO), 1,5-diphenylcarbadiazone (DPDO).

ESI. Table S1. The energy levels complexes Ru(LH4)-Ru(LH6) calculated using LANL2DZ/6-31G* basis set.

Complex	HOMO (eV)	LUMO (eV)	Band Gap (eV)
Ru(LH4)	-5.01	-3.57	1.44
Ru(LH5)	-5.12	-2.50	2.62
Ru(LH6)	-5.06	-3.75	1.31

ESI. Table S2. The λ_{max} data of MLCT of precursor and products of Ru(LH4-6).

	Precursor	Products
Ru(LH4)	Ru(bpy)$_2$Cl$_2$	Ru(bpy)$_2$(DPCO)
λ max (MLCT)	555	524
Ru(LH5)	Ru(phen)$_2$Cl$_2$	Ru(phen)$_2$ (DPCO)
λ max (MLCT)	550	494
Ru(LH6)	Ru(dmbpy)$_2$ Cl$_2$	Ru(dmbpy)$_2$ (DPCO|)
λ max (MLCT)	502	560

ESI. Table S3. E_{ox} data of Ru(III)/Ru(II) potentials for Ru X,Y,Z, complexes measured in organic phase solvent. All data are vs NHE.

Complexes	$E_{Ox}^{1/2}$	Ref
Ru(bpy)$_2$(CH$_3$CN)NO^{+3}	0.8	3
Ru(bpy)$_2$(CH$_3$CN)NO$_2^+$	1.41	3
Ru(bpy)$_2$(CH$_3$CN)N0$_3^+$	1.26	3
Ru(bpy)$_2$(py)N$_3^+$	0.82	3
Ru(bpy)$_2$(py)NO$_2^+$	1.3	3
Ru(bpy)$_2$(py)NO$_3^+$	1.16	3
Ru(bpy)$_2$(4-t-Bupy)NO$_3^+$	1.12	3
Ru(bpy)$_2$(4-vinyl-py)NO$_2^+$	1.27	3
Ru(bpy)$_2$(4-vinyl-py)NO$_3^+$	1.15	3
Ru(bpy)$_2$(Cl)NO$_2$	0.81	3
Ru(bpy)$_2$(Cl)NO$_3$	0.69	3
Ru(bpy)$_2$(py)CH$_3$CN^{+2}	1.6	3
Ru(bpy)$_2$(py)CN$^+$	1.28	3
Ru(bpy)$_2$(py)Cl$^+$	1.01	3
Ru(bpy)$_2$(py)TFA$^+$	1.13	3
Ru(bpy)$_2$(4-Acpy)Cl$^+$	1.06	3
Ru(bpy)$_2$(4-vinyl-py)CH$_3$CN^{2+}	1.53	3
Ru(bpy)$_2$(4-vinyl-py)Cl$^+$	1	3
Ru(bpy)$_2$(pyrimH)Cl^{2+}	1.21	3
Ru(bpy)$_2$(pyr)Cl$^+$	1.12	3
Ru(bpy)$_2$(pyr)NO$_2^{3+}$	1.38	3
Ru(bpy)$_2$(BPA)Cl$^+$	1.01	3
Ru(bpy)$_2$(BPE)Cl$^+$	1.02	3
Ru(bpy)$_2$(MPP)Cl$^+$	1.15	3
Ru(bpy)$_2$(MeP)Cl$^+$	1.18	3
Ru(bpy)$_2$(PDP)Cl$^+$	1.15	3
Ru(bpy)$_2$(PPh$_3$)NO$_2^+$	1.49	3
Ru(bpy)$_2$(PPh$_3$)NO$_3^+$	1.31	3
Ru(bpy)(phendione)$_2^{2+}$	1.67	4
c-Ru(bpy)$_2$(Ph$_2$MeP)Cl$^+$	1.15	5
c-Ru(bpy)$_2$(Ph$_3$P)Cl$^+$	1.18	5
Ru(bpy)(terpy)(CH$_3$CN)$^{2+}$	1.55	3
Ru(bpy)(terpy)(NH$_3$)$^{2+}$	1.41	3
Ru(bpy)(terpy)(CN)$^+$	1.3	6
Ru(bpy)(biq)(4,4-Me$_2$bpy)$^{2+}$	1.54	7
Ru(bpy)(biq)(phen)$^{2+}$	1.59	7
Ru(bpy)(biq)(pq)$^{2+}$	1.63	7
Ru(bpy)(biq)(i-biq)$^{2+}$	1.53	7
Ru(bpy)(biq)(biimH$_2$)$^{2+}$	1.33	7
Ru(bpy)(biq)(bipyrim)$^{2+}$	1.7	7
Ru(bpy)(biq)(binapy)$^{2+}$	1.51	7
Ru(bpy)(biq)Cl$_2$	0.7	8
Ru(bpz)$_2$(CH$_3$CN)Cl$^+$	1.56	9
Ru(bpz)$_2$Cl$_2$	1.04	9
Ru(bpz)$_2$Br$_2$	1.03	10
Ru(bpz)$_2$(NO$_2$)$_2$	1.42	10
Ru(phen)$_2$(CH$_3$CN)$_2^{2+}$	1.68	3
Ru(phen)$_2$(CN)$_2$	1.12	3
Ru(phen)$_2$(py)$_2^{2+}$	1.51	3

Ru(phen)$_2$(4-vinyl-py)$_2$$^{2+}$	1.49	3
Ru(phen)$_2$(pyz)Cl$^+$	1.1	3
Ru(phen)$_2$(naphthyridine)$^{2+}$	1.51	3
Ru(phen)$_2$(py)$_2$$^{2+}$	1.51	11
Ru(phen)$_2$(en)$^{2+}$	1.12	11
Ru(phen)$_2$(py)Cl$^+$	1.04	11
Ru(phen)$_2$(acac)$^+$	0.87	11
Ru(phen)$_2$(ox)	0.72	11
Ru(phen)$_2$Cl$_2$	0.57	11
Ru(4,7-Me$_2$phen)$_2$(pyz)Cl$^+$	1.01	3
Ru(terpy)(BPE)$_3$$^{2+}$	1.47	3
Ru(terpy)(py)$_3$$^{2+}$	1.5	12
Ru(terpy)(CH$_3$CN)$_3$$^{2+}$	1.73	12
c-Ru(terpy)(CH$_3$CN)$_2$ Cl$^+$	1.17	12
t- Ru(terpy)(py)$_2$Cl$^+$	1.07	12
Ru(terpy)(py)$_2$ (CH$_3$CN) $^{2+}$	1.53	12
Ru(terpy)(py)(CH$_3$CN)Cl$^+$	1.09	12
Ru(terpy)(py)(PPh$_3$)Cl$^+$	1.1	12
Ru(pydipy)$_2$(CH$_3$CN)$_2$$^{2+}$	1.6	3
Ru(Azpy)$_2$ Br$_2$	1.19	3
Ru(Azpy)$_2$Cl$_2$	1.20	3
Ru(MeAzpy)$_2$Br$_2$	1.13	3
Ru(MeAzpy)$_2$Cl$_2$	1.14	3
Ru(TZ)(CH$_3$CN)$_2$	1.29	13
Ru(TZ)(py)$_2$	1.05	13
Ru(TZ)(py)(CH$_3$CN)	1.16	13
Ru(TZ)(4,4-bpy)$_2$	1.08	13
Ru(biq)$_2$Cl$_2$	0.72	14
Ru(biq)$_2$(PEt$_3$)H$_2$O^{2+}	1.48	14
Ru(biq)$_2$(CN)$_2$	1.17	6
m-Ru(py)$_3$Cl$_3$	0.08	14
RuBr$_2$(SMe$_2$)$_3$(DMSO)	1.05	15
RuBr$_2$(SEt$_2$)$_3$(DMSO)	1.03	15
RuCl$_2$(SMe$_2$)$_4$	0.80	15
RuCl$_2$(SEt$_2$)$_3$(DMSO)	1.04	15
RuCl$_2$(SMe$_2$)$_2$(DMSO)$_2$	0.94	15
Ru(DMCH)$_2$(CN)$_2$	1.04	6
Ru(i-biq)$_2$(CN)$_2$	1.01	6
Ru(terpy)(dppyz)Cl$^+$	1.18	17
Ru(Azpy)$_2$(N$_3$)$_2$	1.2	3
Ru(bpy)$_2$(CH$_3$CN)Cl$^+$	1.09	3
Ru(bpy)$_2$(NH$_3$)(NO$_2$)$^+$	1.09	3
Ru(bpy)$_2$(NH$_3$)(NO$_3$)$^+$	0.94	3
t-Ru(terpy)(4-pic)$_2$Cl$^+$	1.02	12
Ru(terpy)(4-pic)$_3$$^{2+}$	1.47	12
Ru(terpy)(Py)$_2$(4-pic)$^{2+}$	1.47	12
Ru(bpy)(biq)(PEt$_3$)Cl$^+$	1.19	14
Ru(bpy)(biq)(P(n-Pr)$_3$)Cl$^+$	1.2	14
Ru(bpy)(biq)(P(n-Bu)$_3$)Cl$^+$	1.2	14
Ru(bpy)(biq)(PPh$_3$)Cl$^+$	1.26	14

Ru(LH4)																
Observer	**Illuminant**	**X**	**Y**	**Z**	**x**	**y**	**L**	**a**	**b**	**C(ab)**	**H(ab)**	**u**	**v**	**C(uv)**	**H(uv)**
2-Degree	A	0.1569	0.0853	0.0152	0.6096	0.3315	35.07	41.26	18.22	45.10	23.82	76.37	-2.83	76.42	357.88
	B	0.1125	0.0704	0.0361	0.5139	0.3214	31.89	35.68	12.90	37.94	19.88	57.61	4.59	57.79	4.56
	C	0.1001	0.0659	0.0498	0.4637	0.3053	30.85	31.71	11.17	33.62	19.40	49.13	7.27	49.67	8.42
	D	0.1074	0.0689	0.0350	0.5085	0.3261	31.55	35.63	12.26	37.68	18.99	55.71	3.95	55.85	4.06
	E	0.1094	0.0691	0.0421	0.4960	0.3132	31.59	33.97	12.51	36.20	20.22	54.84	6.24	55.20	6.49
	F2	0.0664	0.0529	0.0279	0.4510	0.3591	27.53	15.35	5.83	16.42	20.79	21.94	1.72	22.00	4.48
	F7	0.0857	0.0610	0.0454	0.4462	0.3175	29.66	27.39	9.35	28.95	18.85	39.98	5.58	40.37	7.94
	F11	0.0655	0.0527	0.0267	0.4522	0.3637	27.50	13.46	5.77	14.65	23.21	19.61	1.81	19.69	5.27
	Blackbody	0.1075	0.0687	0.0364	0.5059	0.3230	31.50	34.51	12.28	36.63	19.59	54.71	4.52	54.90	4.73
	Custom	0.1094	0.0691	0.0421	0.4960	0.3132	31.59	33.97	12.51	36.20	20.22	54.84	6.24	55.20	6.49
10-Degree	A	0.1458	0.0834	0.0149	0.5973	0.3416	34.67	35.62	17.64	39.75	26.35	65.66	-1.61	65.68	358.60
	B	0.1035	0.0684	0.0355	0.4989	0.3299	31.45	30.86	12.24	33.20	21.64	49.29	5.00	49.54	5.79
	C	0.0914	0.0639	0.0487	0.4480	0.3132	30.38	27.41	10.48	29.34	20.92	41.74	7.23	42.36	9.82
	D	0.0990	0.0671	0.0343	0.4941	0.3346	31.13	30.77	11.64	32.90	20.72	47.66	4.36	47.85	5.22
	E	0.1004	0.0671	0.0418	0.4797	0.3205	31.13	29.25	11.84	31.55	22.04	46.74	6.60	47.20	8.04
	F2	0.0660	0.0525	0.0285	0.4488	0.3573	27.44	12.63	5.77	13.89	24.56	18.83	2.18	18.95	6.59
	F7	0.0803	0.0597	0.0448	0.4345	0.3233	29.34	23.37	8.91	25.01	20.86	34.15	5.74	34.63	9.55
	F11	0.0651	0.0525	0.0271	0.4500	0.3627	27.43	11.42	5.74	12.78	26.70	17.19	2.18	17.33	7.22
	Blackbody	0.0992	0.0669	0.0360	0.4910	0.3307	31.08	29.70	11.68	31.92	21.46	46.75	4.99	47.01	6.09
	Custom	0.1004	0.0671	0.0418	0.4797	0.3205	31.13	29.25	11.84	31.55	22.04	46.74	6.60	47.20	8.04

Working Space	**Reference Illuminant**	**Range = [0.0, 1.0]**			**Range = [0, 255]**		
		Red	**Green**	**Blue**	**Red**	**Green**	**Blue**
Adobe RGB (1998)	D65	0.4123	0.2051	0.2323	105	52	59
Apple RGB	D65	0.3815	0.1339	0.1694	97	34	43
Best RGB	D50	0.4176	0.2470	0.2375	106	63	61
Beta RGB	D50	0.4132	0.2215	0.2384	105	56	61
Bruce RGB	D65	0.4451	0.2051	0.2323	114	52	59
CIE RGB	E	0.4556	0.2466	0.2368	116	63	60
Color Match RGB	D50	0.3927	0.1228	0.1681	100	31	43
Don RGB 4	D50	0.4179	0.2282	0.2366	107	58	60
ECI RGB v2	D50	0.4535	0.2011	0.2478	116	51	63
Ekta Space PS5 RGB	D50	0.4304	0.2262	0.2382	110	58	61
NTSC RGB	C	0.4114	0.2084	0.2388	105	53	61
PAL/SECAM RGB	D65	0.4590	0.2051	0.2337	117	52	60
ProPhoto RGB	D50	0.3153	0.1810	0.1727	80	46	44
SMPTE-C RGB	D65	0.4779	0.1949	0.2339	122	50	60
sRGB	D65	0.4695	0.1919	0.2230	120	49	57
Wide Gamut RGB	D50	0.4023	0.2467	0.2370	103	63	60

Density	**Red**	**Green**	**Blue**	**Visual**
Status A	0.648	1.352	1.383	-
Status E	1.057	1.354	1.384	-
Status M	0.267	1.352	1.373	-
Status T	1.057	1.354	1.372	-

Visual	-	-	-	1.069
Type 1	-	-	-	1.400
Type 2	-	-	-	1.399

Continued ESI. Table S4.

							Ru(LH5)								
Observer	Illuminant	X	Y	Z	x	y	L	a	b	C(ab)	H(ab)	u	v	C(uv)	H(uv)
2-Degree	A	0.2181	0.0970	0.0073	0.6766	0.3009	37.29	61.97	37.20	72.28	30.97	125.49	-4.47	125.57	357.96
	B	0.1487	0.0708	0.0174	0.6278	0.2988	31.98	58.88	28.09	65.24	25.50	107.04	8.05	107.35	4.30
	C	0.1278	0.0627	0.0241	0.5956	0.2922	30.08	54.87	24.83	60.23	24.35	96.75	13.24	97.65	7.80
	D	0.1419	0.0684	0.0168	0.6248	0.3011	31.44	59.51	27.14	65.40	24.52	104.93	7.00	105.16	3.82
	E	0.1433	0.0686	0.0204	0.6170	0.2954	31.49	56.94	27.29	63.15	25.61	104.04	11.04	104.62	6.06
	F2	0.0763	0.0426	0.0137	0.5753	0.3213	24.52	38.00	15.26	40.95	21.88	58.35	2.31	58.39	2.27
	F7	0.1078	0.0552	0.0221	0.5822	0.2982	28.18	51.63	21.56	55.95	22.66	85.07	10.00	85.66	6.71
	F11	0.0933	0.0515	0.0131	0.5906	0.3264	27.17	39.94	19.81	44.59	26.38	65.97	3.71	66.07	3.22
	Blackbody	0.1417	0.0682	0.0176	0.6231	0.2997	31.39	58.06	27.09	64.07	25.02	103.80	7.95	104.11	4.38
	Custom	0.1433	0.0686	0.0204	0.6170	0.2954	31.49	56.94	27.29	63.15	25.61	104.04	11.04	104.62	6.06
10-Degree	A	0.2006	0.0946	0.0072	0.6635	0.3128	36.85	54.76	36.48	65.80	33.67	110.23	-2.62	110.26	358.64
	B	0.1340	0.0679	0.0172	0.6117	0.3100	31.32	52.55	27.00	59.08	27.19	94.03	8.83	94.44	5.37
	C	0.1138	0.0597	0.0236	0.5775	0.3028	29.33	49.16	23.58	54.52	25.63	84.52	13.29	85.56	8.94
	D	0.1280	0.0657	0.0166	0.6089	0.3124	30.80	53.08	26.09	59.14	26.18	92.17	7.77	92.50	4.82
	E	0.1287	0.0657	0.0203	0.5995	0.3059	30.80	50.72	26.13	57.05	27.26	91.18	11.80	91.94	7.37
	F2	0.0728	0.0422	0.0140	0.5641	0.3272	24.39	32.42	15.07	35.76	24.93	51.04	3.41	51.15	3.82
	F7	0.0979	0.0533	0.0219	0.5657	0.3078	27.64	45.64	20.67	50.10	24.37	74.45	10.43	75.17	7.97
	F11	0.0896	0.0512	0.0133	0.5812	0.3323	27.09	35.24	19.70	40.38	29.21	59.31	4.79	59.50	4.62
	Blackbody	0.1280	0.0655	0.0175	0.6067	0.3106	30.76	51.65	26.05	57.84	26.77	91.11	8.84	91.53	5.55
	Custom	0.1287	0.0657	0.0203	0.5995	0.3059	30.80	50.72	26.13	57.05	27.26	91.18	11.80	91.94	7.37

Working	Reference	Range = [0.0, 1.0]			Range = [0, 255]		
Space	Illuminant	Red	Green	Blue	Red	Green	Blue
Adobe RGB (1998)	D65	0.4889	-0.0756	0.1568	125	-19	40
Apple RGB	D65	0.4846	-0.0803	0.1082	124	-20	28
Best RGB	D50	0.4938	0.1910	0.1702	126	49	43
Beta RGB	D50	0.4872	0.1117	0.1728	124	28	44
Bruce RGB	D65	0.5387	-0.0756	0.1566	137	-19	40
CIE RGB	E	0.5500	0.1903	0.1701	140	49	43
ColorMatch RGB	D50	0.4975	-0.1030	0.1038	127	-26	26
Don RGB 4	D50	0.4942	0.1370	0.1677	126	35	43
ECI RGB v2	D50	0.5343	0.0000	0.1676	136	0	43
Ekta Space PS5 RGB	D50	0.5130	0.1300	0.1723	131	33	44
NTSC RGB	C	0.4853	-0.0470	0.1752	124	-12	45
PAL/SECAM RGB	D65	0.5595	-0.0756	0.1614	143	-19	41
ProPhoto RGB	D50	0.3769	0.1322	0.1150	96	34	29
SMPTE-C RGB	D65	0.5873	-0.1207	0.1618	150	-31	41
sRGB	D65	0.5759	-0.0440	0.1421	147	-11	36
Wide Gamut RGB	D50	0.4705	0.1906	0.1690	120	49	43

Density	Red	Green	Blue	Visual
Status A	0.390	1.693	1.693	-
Status E	0.837	1.693	1.695	-
Status M	0.111	1.695	1.691	-
Status T	0.837	1.693	1.690	-

Visual	-	-	-	1.013
Type 1	-	-	-	1.708
Type 2	-	-	-	1.701

Continued ESI. Table S4.

		Ru(LH6)														
Observer	Illuminant	X	Y	Z	x	y	L	a	b	C(ab)	H(ab)	u	v	C(uv)	H(uv)
2-Degree	A	0.0656	0.0414	0.0101	0.5598	0.3539	24.14	22.37	8.19	23.82	20.12	34.37	-1.40	34.40	357.67
	B	0.0489	0.0365	0.0241	0.4467	0.3330	22.47	17.61	5.39	18.41	17.03	23.11	1.74	23.17	4.30
	C	0.0447	0.0351	0.0334	0.3952	0.3097	21.96	14.99	4.55	15.67	16.87	18.79	2.71	18.98	8.20
	D	0.0469	0.0360	0.0234	0.4413	0.3389	22.31	17.39	5.08	18.12	16.28	22.12	1.48	22.17	3.82
	E	0.0481	0.0361	0.0282	0.4279	0.3212	22.33	16.58	5.22	17.38	17.49	21.72	2.39	21.85	6.28
	F2	0.0329	0.0306	0.0187	0.4008	0.3718	20.27	4.40	1.99	4.83	24.40	5.39	0.74	5.44	7.86
	F7	0.0385	0.0331	0.0303	0.3777	0.3245	21.23	11.22	3.53	11.76	17.48	13.32	2.02	13.47	8.64
	F11	0.0322	0.0301	0.0179	0.4017	0.3755	20.09	3.02	1.67	3.46	28.97	3.81	0.67	3.87	10.00
	Blackbody	0.0470	0.0359	0.0244	0.4383	0.3346	22.26	16.66	5.06	17.41	16.89	21.47	1.70	21.54	4.53
	Custom	0.0481	0.0361	0.0282	0.4279	0.3212	22.33	16.58	5.22	17.38	17.49	21.72	2.39	21.85	6.28
10-Degree	A	0.0613	0.0405	0.0100	0.5485	0.3622	23.82	18.65	7.71	20.18	22.46	28.53	-0.81	28.54	358.38
	B	0.0457	0.0357	0.0238	0.4345	0.3394	22.20	14.62	4.98	15.44	18.83	19.03	1.87	19.13	5.61
	C	0.0417	0.0343	0.0327	0.3832	0.3159	21.70	12.41	4.16	13.08	18.54	15.36	2.65	15.59	9.78
	D	0.0440	0.0353	0.0230	0.4300	0.3452	22.05	14.42	4.70	15.16	18.06	18.22	1.62	18.29	5.07
	E	0.0449	0.0353	0.0281	0.4145	0.3261	22.05	13.67	4.82	14.50	19.42	17.79	2.49	17.96	7.97
	F2	0.0336	0.0304	0.0191	0.4041	0.3663	20.22	3.46	1.98	3.99	29.73	4.51	0.87	4.59	10.97
	F7	0.0370	0.0326	0.0300	0.3713	0.3279	21.07	9.17	3.32	9.75	19.91	11.00	2.06	11.20	10.62
	F11	0.0326	0.0300	0.0182	0.4038	0.3714	20.05	2.39	1.65	2.91	34.65	3.19	0.76	3.27	13.39
	Blackbody	0.0441	0.0352	0.0242	0.4265	0.3399	22.00	13.75	4.69	14.52	18.84	17.64	1.86	17.74	6.01
	Custom	0.0449	0.0353	0.0281	0.4145	0.3261	22.05	13.67	4.82	14.50	19.42	17.79	2.49	17.96	7.97

Working Space	Reference Illuminant	Range = [0.0, 1.0]			Range = [0, 255]		
		Red	Green	Blue	Red	Green	Blue
Adobe RGB (1998)	D65	0.2722	0.1864	0.1959	69	48	50
Apple RGB	D65	0.2227	0.1251	0.1369	57	32	35
Best RGB	D50	0.2762	0.2008	0.1978	70	51	50
Beta RGB	D50	0.2741	0.1915	0.1982	70	49	51
Bruce RGB	D65	0.2880	0.1864	0.1959	73	48	50
CIE RGB	E	0.2951	0.2007	0.1974	75	51	50
ColorMatch RGB	D50	0.2295	0.1211	0.1365	59	31	35
Don RGB 4	D50	0.2764	0.1939	0.1975	70	49	50
ECI RGB v2	D50	0.2927	0.1770	0.1949	75	45	50
Ekta Space PS5 RGB	D50	0.2825	0.1932	0.1981	72	49	51
NTSC RGB	C	0.2722	0.1873	0.1983	69	48	51
PAL/SECAM RGB	D65	0.2948	0.1864	0.1964	75	48	50
ProPhoto RGB	D50	0.1950	0.1406	0.1380	50	36	35
SMPTE-C RGB	D65	0.3042	0.1832	0.1965	78	47	50
sRGB	D65	0.2934	0.1712	0.1822	75	44	46
Wide Gamut RGB	D50	0.2688	0.2007	0.1976	69	51	50

Density	Red	Green	Blue	Visual
Status A	1.197	1.537	1.546	-
Status E	1.445	1.537	1.555	-

Status M	0.723	1.538	1.546	-
Status T	1.445	1.537	1.548	-
Visual	-	-	-	1.382
Type 1	-	-	-	1.574
Type 2	-	-	-	1.564
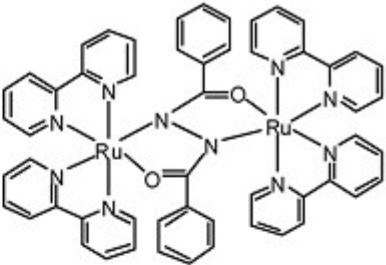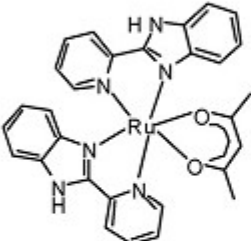
Continued ESI. Table S4.

							$Ru(bpy)_3^{2+}$									
Observer	Illuminant	X	Y	Z	x	y	L	a	b	C(ab)	H(ab)	u	v	C(uv)	H(uv)
2-Degree	A	0.4688	0.3133	0.0668	0.5522	0.3691	62.79	36.85	21.31	42.57	30.04	76.16	0.75	76.16	0.56
	B	0.3697	0.2807	0.1591	0.4567	0.3467	59.95	32.56	16.68	36.59	27.13	61.35	11.18	62.36	10.33
	C	0.3424	0.2700	0.2199	0.4114	0.3244	58.97	28.90	15.11	32.61	27.60	53.81	15.42	55.98	15.99
	D	0.3580	0.2778	0.1541	0.4532	0.3517	59.69	33.10	16.15	36.83	26.01	60.45	10.24	61.31	9.61
	E	0.3654	0.2782	0.1855	0.4407	0.3355	59.72	31.05	16.51	35.16	28.00	59.27	13.80	60.86	13.10
	F2	0.3116	0.2618	0.1237	0.4470	0.3756	58.21	20.03	14.29	24.60	35.52	37.92	8.73	38.91	12.96
	F7	0.3177	0.2631	0.2005	0.4066	0.3367	58.33	26.62	14.32	30.22	28.28	48.00	13.81	49.94	16.05
	F11	0.3544	0.2783	0.1182	0.4720	0.3706	59.74	26.27	16.91	31.24	32.76	50.64	8.73	51.38	9.78
	Blackbody	0.3618	0.2783	0.1604	0.4519	0.3477	59.74	32.05	16.42	36.02	27.13	59.78	11.28	60.84	10.68
	Custom	0.3654	0.2782	0.1855	0.4407	0.3355	59.72	31.05	16.51	35.16	28.00	59.27	13.80	60.86	13.10
10-Degree	A	0.4553	0.3101	0.0658	0.5477	0.3731	62.52	32.89	21.06	39.06	32.63	68.55	1.59	68.57	1.33
	B	0.3549	0.2758	0.1565	0.4508	0.3504	59.51	29.48	16.12	33.60	28.67	55.61	11.15	56.71	11.34
	C	0.3260	0.2645	0.2149	0.4048	0.3284	58.46	26.35	14.41	30.03	28.67	48.70	14.81	50.90	16.91
	D	0.3443	0.2732	0.1513	0.4478	0.3553	59.27	29.93	15.61	33.76	27.55	54.81	10.22	55.75	10.56
	E	0.3500	0.2730	0.1844	0.4335	0.3381	59.25	28.03	15.90	32.22	29.57	53.61	13.77	55.35	14.41
	F2	0.3158	0.2600	0.1261	0.4499	0.3704	58.03	17.73	14.17	22.69	38.63	35.29	9.21	36.47	14.63
	F7	0.3085	0.2589	0.1977	0.4031	0.3384	57.94	24.02	13.80	27.70	29.88	43.78	13.50	45.82	17.14
	F11	0.3548	0.2768	0.1200	0.4720	0.3683	59.60	23.64	16.82	29.02	35.43	47.14	9.37	48.06	11.24
	Blackbody	0.3483	0.2737	0.1589	0.4461	0.3504	59.31	28.92	15.89	32.99	28.79	54.19	11.36	55.37	11.84
	Custom	0.3500	0.2730	0.1844	0.4335	0.3381	59.25	28.03	15.90	32.22	29.57	53.61	13.77	55.35	14.41

Working Space	Reference Illuminant	Range = [0.0, 1.0]			Range = [0, 255]		
		Red	Green	Blue	Red	Green	Blue
Adobe RGB (1998)	D65	0.7002	0.4695	0.4570	179	120	117
Apple RGB	D65	0.7089	0.3868	0.3826	181	99	98
Best RGB	D50	0.6991	0.5098	0.4659	178	130	119
Beta RGB	D50	0.6936	0.4866	0.4654	177	124	119
Bruce RGB	D65	0.7422	0.4695	0.4570	189	120	117
CIE RGB	E	0.7483	0.5078	0.4645	191	129	118
ColorMatch RGB	D50	0.7140	0.3814	0.3807	182	97	97
Don RGB 4	D50	0.6994	0.4924	0.4644	178	126	118
ECI RGB v2	D50	0.7346	0.5109	0.5024	187	130	128
Ekta Space PS5 RGB	D50	0.7141	0.4896	0.4651	182	125	119
NTSC RGB	C	0.6934	0.4771	0.4651	177	122	119
PAL/SECAM RGB	D65	0.7602	0.4695	0.4563	194	120	116
ProPhoto RGB	D50	0.6035	0.4390	0.3937	154	112	100
SMPTE-C RGB	D65	0.7852	0.4614	0.4572	200	118	117
sRGB	D65	0.7753	0.4725	0.4591	198	120	117
Wide Gamut RGB	D50	0.6815	0.5083	0.4635	174	130	118

Density	Red	Green	Blue	Visual
Status A	0.199	0.693	0.736	-
Status E	0.353	0.693	0.740	-
Status M	0.070	0.684	0.728	-
Status T	0.353	0.693	0.729	-
Visual	-	-	-	0.504
Type 1	-	-	-	0.766
Type 2	-	-	-	0.781

ESI. Table S5. The molecular structures and EL properties of near infrared light electrochemical cell based on ruthenium polypyridyl complexes
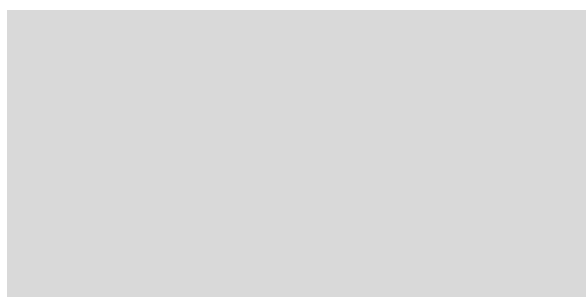
Complexes	Cell configuration	EL$_{max}$ (nm)	η_{ext} (%)	Ref.
	ITO/complex (100 nm)/Au (100 nm)	630	0.31	(18)
	ITO/complex (100 nm)/Au (100 nm)	780	0.013	(18)
	ITO/complex (100 nm)/Au (100 nm)	880	0.075	(18)

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[1](PF₆)₂

[2](PF₆)₂: R¹ = COOEt; R² = H
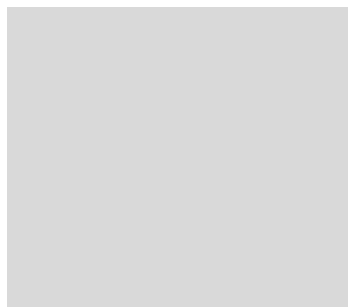
Structure	Device			Ref
	ITO/complex (100 nm)/Au (100 nm)	900	0.06	(18)
	ITO/complex (100 nm)/Au (100 nm)	945	0.03	(18)
	ITO/complex (100 nm)/Au (100 nm)	1040	-	(18)
[1](PF₆)₂	ITO/PEDOT: PSS(45nm)/Ru:PMMA (169-194 nm)/Ag	733	0.001	(19)
[2](PF₆)₂	ITO/PEDOT: PSS(45nm)/Ru:PMMA (169-194 nm)/Ag	722	0.028	(19)
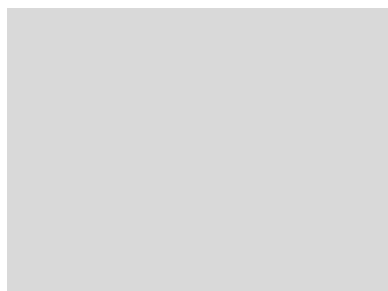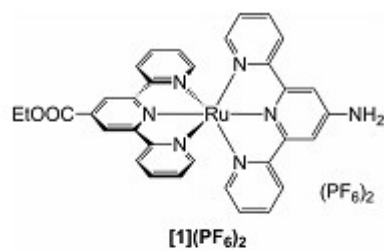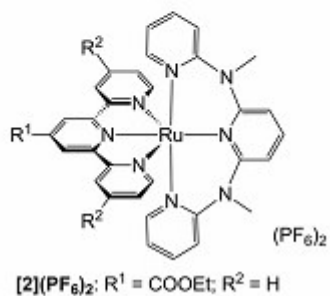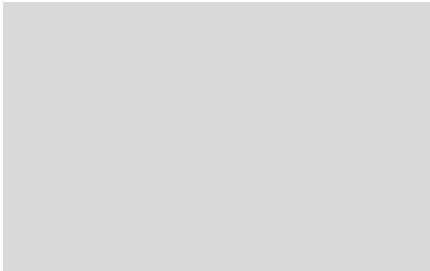
	ITO/PEDOT:PSS(45nm)/Ru:PMMA (169-194 nm)/Ag	745	0.013	(19)
(PF$_6$)$_2$	ITO/PEDOT:PSS(30nm)/Ru/Ag	600, 720	2.06 ,0.27(after 100 min)	(20)
1: R=H	TO/PEDOT:PSS/ complex:PMMA/Al	717	0.005	(21)
2: R= CO$_2$Et	TO/PEDOT:PSS/ complex:PMMA/Al	725	0.005	(21)
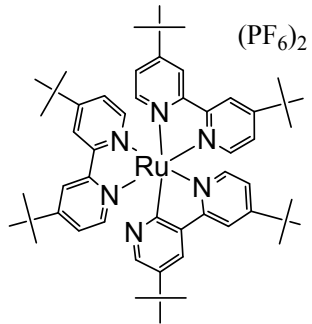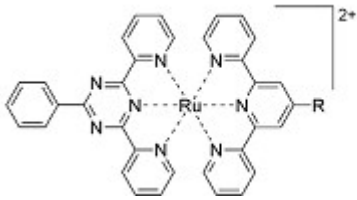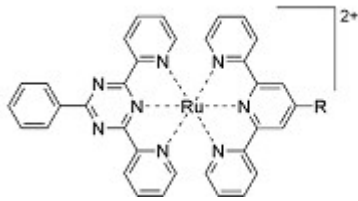
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