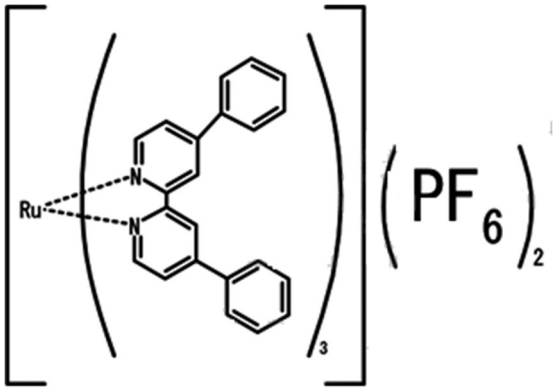
Ru Complex

Complex name	Tris(4,4'-diphenyl-2,2'-bipyridinato) ruthenium(Ⅱ) dihexafluorophosphate
CAS No.	123335-77-9
Abbreviation	$[Ru(dpbpy)_3](PF_6)_2$
Molecular formula/weight	$C_{66}H_{48}F_{12}RuN_6P_2$ 1316.15
Form	Powder

Structural formula



This is a cationic, homoleptic complex of Ruthenium(II). Unlike the Ir(III) complexes discussed earlier, Ru(II) in this context has a +2 charge, which is balanced by two PF_6^- counterions.

The 4,4'-diphenyl-2,2'-bipyridine (dpbpy) ligand extends the π-conjugation compared to the parent 2,2'-bipyridine (bpy). This significantly alters the electronic properties, leading to a red-shift in absorption and emission.

Key Properties:

Luminescence: It is a strong red-emitting luminophore. The emission is from a Metal-to-Ligand Charge Transfer (MLCT) excited state, where an electron is promoted from the ruthenium metal center to the π* orbital of the diphenylbipyridine ligand.

Long-Lived Excited State: Like other Ru(II) polypyridyl complexes, it has a long-lived triplet excited state (microsecond to nanosecond range), which is crucial for its applications.

Electrochemical Activity: It undergoes reversible Ru(II)/Ru(III) oxidation, making it useful in electrochemistry.

Its primary applications are in research, including:

Electrochemiluminescence (ECL): It is an extremely efficient and stable ECL emitter, widely used in commercial clinical immunoassay analyzers and biosensors.

Organic Light-Emitting Diodes (OLEDs) as a phosphorescent dopant.

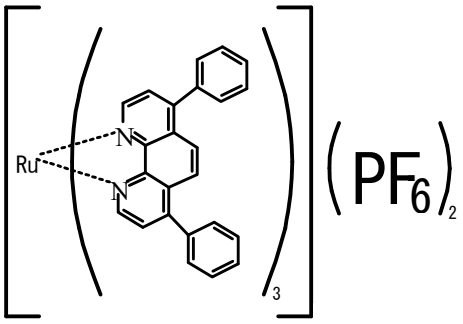
Dye-Sensitized Solar Cells (DSSCs) as a sensitizer.

Photoredox Catalysis as a photocatalyst.

Luminescent Sensors and Probes.

Complex name	Tris(4,7-diphenyl-1,10-phenantrolinato) ruthenium(Ⅱ) dihexafluorophosphate
CAS No.	65186-19-0
Abbreviation	$[Ru(dpphen)_3](PF_6)_2$
Molecular formula/weight	$C_{72}H_{42}F_{12}RuN_6P_2$ 1382.17
Form	Powder

Structural formula



Cationic, homoleptic complex of Ruthenium(II). The +2 charge on the complex is balanced by two PF_6^- counterions.

The 4,7-diphenyl-1,10-phenanthroline (dpp or bathophenanthroline) ligand is a highly conjugated and hydrophobic system. The phenyl rings extend the π-system and create a rigid, sterically protected environment around the ruthenium center.

Key Properties:

Strong Red Luminescence: It is one of the most intensely luminescent Ru(II) complexes, emitting in the orange-red to red region (around 600-620 nm). The extended conjugation of the dpp ligand lowers the energy of the ligand-centered π* orbital, resulting in a lower-energy Metal-to-Ligand Charge Transfer (MLCT) excited state compared to $Ru(bpy)_3^{2+}$.

Long-Lived Excited State: It possesses a long-lived triplet MLCT excited state, which is essential for its applications in sensing and light-emitting devices.

High Lipophilicity: The phenyl substituents make the complex very hydrophobic, which can be advantageous for incorporating it into polymers or membranes.

Its primary applications are in research and technology, including:

Oxygen Sensing: This is a flagship application. The long-lived luminescence of $Ru(dpp)_3^{2+}$ is efficiently quenched by molecular oxygen. E xploited in optical oxygen sensors for biomedical, environmental, and industrial monitoring.

Electrochemiluminescence (ECL): It is an extremely efficient and stable ECL emitter, widely used in analytical chemistry and clinical diagnostics.

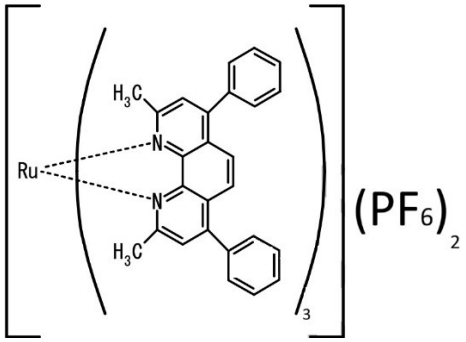
Organic Light-Emitting Diodes (OLEDs) as a red phosphorescent dopant.

Dye-Sensitized Solar Cells (DSSCs) as a sensitizer.

Luminescent Labels in bioassays

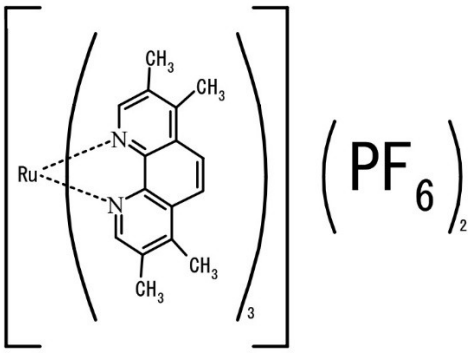
Complex name	Tris(2,9-dimethyl-4,7-diphenyl-1,10-phenanthrolinato) ruthenium(II) dihexafluorophosphate
CAS No.	157081-88-8
Abbreviation	$Ru(bathocuproine)_3(PF_6)_2$
Molecular formula/weight	$C_{72}H_{60}F_{12}RuN_6P_2$ 1400.31
Form	Powder

Structural formula



This is the hexafluorophosphate salt of the $[Ru(bcp)_3]^{2+}$ cation.
The ligand is bathocuproine (bcp), which is 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline. The methyl groups at the 2 and 9 positions create significant steric hindrance, forcing the three bulky ligands into a distorted, propeller-like arrangement around the ruthenium center.
The PF_6^- counterion is non-coordinating and, crucially, makes the complex much safer to handle than the corresponding shock-sensitive perchlorate salt.
Key Property: This complex is a red-emitting phosphorescent compound. The extended π-system of the diphenylphenanthroline ligand leads to a low-energy Metal-to-Ligand Charge Transfer (MLCT) excited state, resulting in red emission. The steric hindrance can influence the emission efficiency and excited-state lifetime.
Its primary applications are in research:
Electrochemiluminescence (ECL) studies
As a dopant in Light-Emitting Diodes (OLEDs) and Light-Emitting Electrochemical Cells (LEECs).
Fundamental photophysical studies of sterically constrained ruthenium complexes.

Complex name	Tris(3,4,7,8-tetramethyl-1,10-phenantrolinato) ruthenium(Ⅱ) dihexafluorophosphate
CAS No.	65186-18-9
Abbreviation	〔Ru(tmphen)$_3$〕(PF6)$_2$
Molecular formula/weight	$C_{48}H_{48}F_{12}RuN_6P_2$ 1099.95
Form	Powder
Structural formula	



This is a cationic, homoleptic complex of Ruthenium(II). The +2 charge is balanced by two PF_6^- counterions.

The 3,4,7,8-tetramethyl-1,10-phenanthroline (tm phen) ligand is a sterically hindered and electron-rich variant of 1,10-phenanthroline. The methyl groups donate electron density and create a protected environment around the metal center.

Key Properties:

Red-Emitting Luminophore: It is a strong red-emitting complex. The methyl substituents cause a slight red-shift in emission compared to the unsubstituted $Ru(phen)_3^{2+}$ complex, due to their electron-donating nature which raises the energy of the metal d-orbitals, lowering the MLCT energy gap.

Hydrophobicity & Solubility: The methyl groups make the complex more soluble in organic solvents and can be used to incorporate it into hydrophobic matrices.

Oxygen Sensing: Like other long-lived Ru(II) complexes, its phosphorescence can be quenched by oxygen, making it useful in optical oxygen sensing applications.

Its primary applications are in research, including:

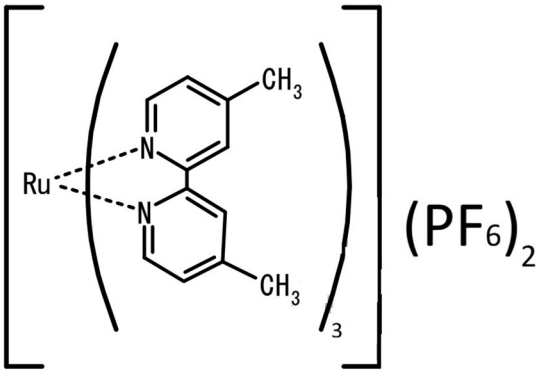
Oxygen Sensors: Particularly in hydrophobic polymer films.

Electrochemiluminescence (ECL): As a stable emitter.

Light-Emitting Devices (OLEDs/LEECs): As a red phosphorescent dopant.

Fundamental Photophysical Studies: To understand the impact of alkyl substitution on the properties of polypyridyl complexes.

Complex name	Tris(4,4’-dimethyl-2,2’-bipyridinato) ruthenium(Ⅱ) dihexafluorophosphate
CAS No.	78746-15-9.
Abbreviation	$Ru(dmbpy)_3(PF_6)_2$
Molecular formula/weight	$C_{36}H_{36}F_{12}RuN_6P_2$ 943.72
Form	Powder
Structural formula	



Cationic, homoleptic complex of Ruthenium(II). The +2 charge is balanced by two PF_6^- counterions. The 4,4'-dimethyl-2,2'-bipyridine (dmbpy) ligand features electron-donating methyl groups. This electronic modification subtly tunes the properties of the complex compared to the parent $Ru(bpy)_3^{2+}$.

Key Properties:

Orange-Red Luminescence: It is a strong emitter in the orange-red region. The electron-donating methyl groups cause a slight blue-shift (higher energy) in its emission compared to $Ru(bpy)_3^{2+}$. This is because the methyl groups raise the energy of the π* orbital on the ligand, increasing the energy gap for the Metal-to-Ligand Charge Transfer (MLCT) transition.

More Positive Oxidation Potential: The electron-donating methyl groups make the ruthenium center slightly more difficult to oxidize (Ru^{2+}/Ru^{3+} couple is more positive) than in $Ru(bpy)_3^{2+}$.

Hydrophobicity: The methyl groups increase the complex's solubility in organic solvents.

Its primary applications mirror those of $Ru(bpy)_3^{2+}$ but are chosen when its specific redox potential or emission energy is required:

Electrochemiluminescence (ECL): A very common and efficient ECL emitter.

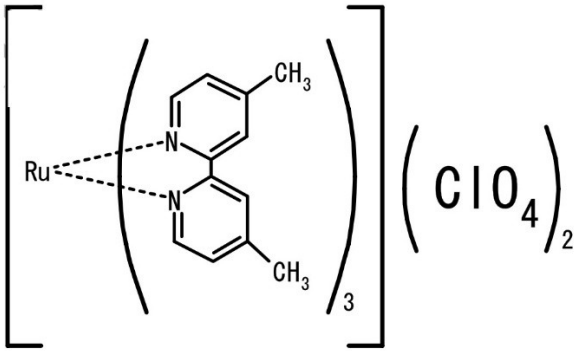
Photoredox Catalysis: Used as a photocatalyst, often in dual catalytic systems.

Dye-Sensitized Solar Cells (DSSCs): As a sensitizer.

Fundamental Research: As a model compound for studying the effects of electron-donating substituents on photophysical and electrochemical properties.

Complex name	Tris(4,4’-dimethyl-2,2’-bipyridinato)ruthenium(II) diperchlorate
CAS No.	78746-16-0
Abbreviation	$Ru(dmbpy)_3(ClO_4)_2$
Molecular formula/weight	$C_{36}H_{36}Cl_2RuN_6O_8$ 852.69
Form	Powder

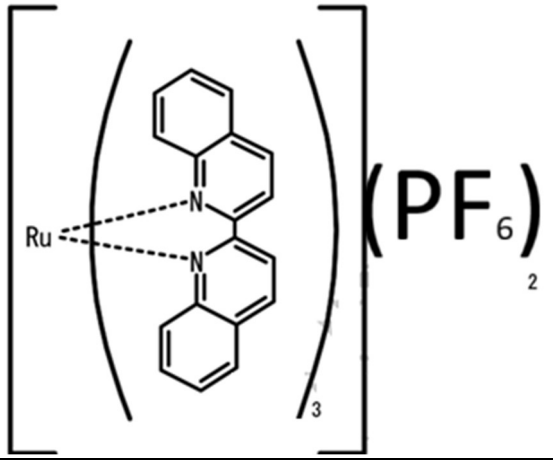
Structural formula



This is the perchlorate salt of the $[Ru(dmb)_3]^{2+}$ cation.
The ligand is 4,4'-dimethyl-2,2'-bipyridine (dmbpy), whose electron-donating methyl groups cause a slight blue-shift in emission and a more positive oxidation potential compared to the parent $Ru(bpy)_3^{2+}$ complex.
This compound is a perchlorate salt. Metal complexes with organic ligands and perchlorate (ClO_4^-) counterions are generally considered shock-sensitive and potentially explosive, especially when dry. For this reason, the hexafluorophosphate (PF_6^-) salt (CAS # 78746-15-9) is the preferred and much safer form for laboratory use.
Key Property: The $[Ru(dmb)_3]^{2+}$ cation is a strong orange-red emitting luminophore with a long-lived triplet Metal-to-Ligand Charge Transfer (^{3}MLCT) excited state.
Its primary applications (for which the safer PF_6^- salt is strongly recommended) are in research:
Electrochemiluminescence (ECL)
Photoredox Catalysis
Fundamental Photophysical and Electrochemical Studies

Complex name	Tris(2,2'-biquinolinato) ruthenium(Ⅱ) ihexafluorophosphate
CAS No.	84649-52-7
Abbreviation	$[Ru(bqn)_3](PF_6)_2$
Molecular formula/weight	$C_{54}H_{48}F_{12}RuN_6P_2$ 1172.02
Form	PowderStructural formula

Structural formula



Cationic, homoleptic complex of Ruthenium(II). The +2 charge is balanced by two PF_6^- counterions.

The 2,2'-biquinoline (biq) ligand is a larger, more extended, and more π-delocalized analog of 2,2'-bipyridine (bpy). This expanded structure significantly lowers the energy of the ligand's π* orbital.

Key Properties:

Near-Infrared (NIR) Luminescence: $Ru(biq)_3^{2+}$ is renowned for its emission in the deep red to near-infrared (NIR) region. This is a direct result of the low-energy π* orbital of the biq ligand, which leads to a very low-energy Metal-to-Ligand Charge Transfer (MLCT) excited state. Its emission is among the lowest in energy for simple Ru(II) polypyridyl complexes.

Electrochemical Properties: It exhibits a relatively easy-to-oxidize Ru(II/III) couple due to the strong π-acceptor character of the biq ligands.

Its primary applications are in specialized research areas, including:

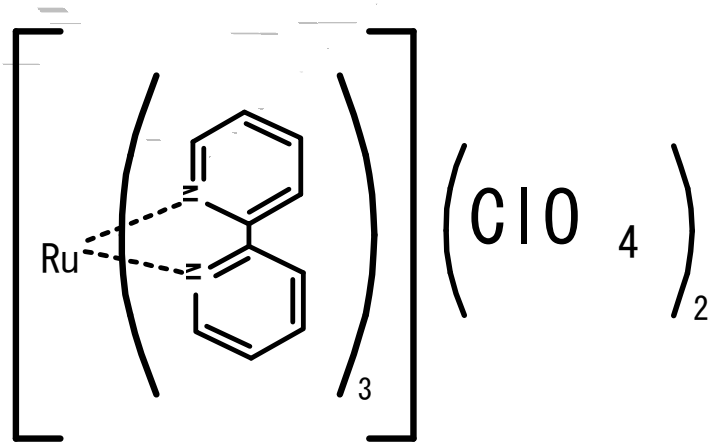
Spectroscopic Probes: Its NIR emission is useful in systems where visible light emission would be interfering or absorbed.

Electrochemiluminescence (ECL): Used as an ECL emitter, particularly in studies focusing on the red/NIR part of the spectrum.

Fundamental Photophysical Studies: It serves as a benchmark complex for studying low-energy excited states and electron transfer processes in transition metal complexes.

Complex name	Tris(2,2'-bipyridinato) ruthenium(Ⅱ) diperchlorate
CAS No.	65009-85-4
Abbreviation	$[Ru(bpy)_3](ClO_4)_2$
Molecular formula/weight	$C_{30}H_{24}Cl_2RuN_6O_8$ 768.53
Form	Powder

Structural formula



This is the perchlorate salt of the most famous and foundational ruthenium polypyridyl complex, $[Ru(bpy)_3]^{2+}$.

The perchlorate (ClO_4^-) anion is a weakly coordinating ion, which means it does not interfere with the photophysical and electrochemical properties of the $Ru(bpy)_3^{2+}$ cation.

⚠ CRITICAL SAFETY WARNING:

Perchlorate salts of metal complexes with organic ligands are potentially explosive. They are considered shock-sensitive and can be hazardous, especially when dry. For this reason, the hexafluorophosphate (PF_6^-) salt of $Ru(bpy)_3^{2+}$ (CAS # 60804-75-1) is much more commonly used in modern research due to its superior stability and safety.

Key Property: The $[Ru(bpy)_3]^{2+}$ cation is a benchmark complex in inorganic photophysics and electrochemistry. It is famous for its:

Intense Orange-Red Luminescence: Emitting from a long-lived, triplet Metal-to-Ligand Charge Transfer (^{3}MLCT) excited state.

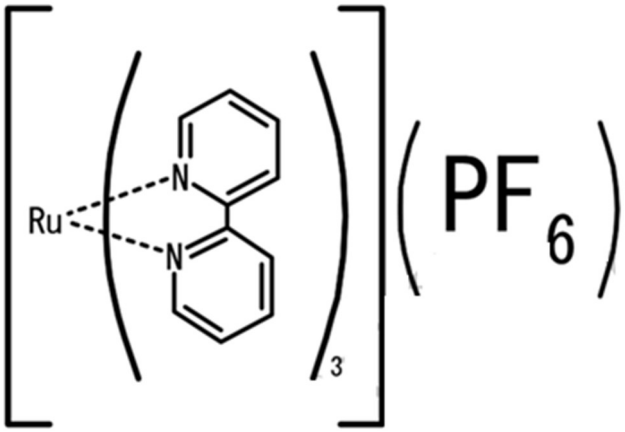
Chemical Stability: The complex is very stable and robust.

Reversible Electrochemistry: Exhibiting a well-defined Ru(II)/Ru(III) oxidation wave.

Strong Electrochemiluminescence (ECL): It is the prototypical and most widely studied ECL compound.

Its primary applications the safer PF_6^- salt: Electrochemiluminescence (ECL) Sensors: The basis for many commercial clinical diagnostic systems, Dye-Sensitized Solar Cells (DSSCs) as a standard sensitizer, Photoredox Catalysis as a pioneering photocatalyst, Fundamental Research as a model compound for studying electron and energy transfer processes

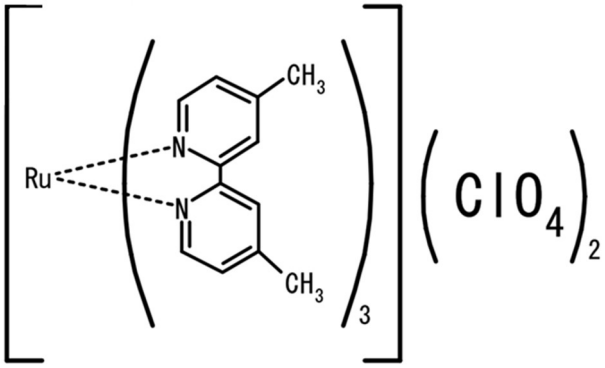
Complex name	Tris(2,2’-bipyridinato) ruthenium(Ⅱ) dihexafluorophosphate
CAS No.	60804-75-1
Abbreviation	$[Ru(bpy)_3](PF_6)_2$
Molecular formula/weight	$C_{30}H_{24}F_{12}RuN_6P_2$ 859.56
Form	Powder
Structural formula	



This is the hexafluorophosphate salt of the iconic $[Ru(bpy)_3]^{2+}$ cation.
The PF_6^- anion is preferred over others (like perchlorate, ClO_4^-) due to its chemical stability, non-coordinating nature, and low shock-sensitivity, making it safe to handle and store.
Key Properties:
Intense Orange Photoluminescence: It exhibits strong emission from a long-lived triplet Metal-to-Ligand Charge Transfer (^{3}MLCT) excited state.
Excellent Redox Stability: It undergoes a reversible one-electron oxidation (Ru^{2+}/Ru^{3+}) and reduction (on the bipyridine ligands).
Strong Electrochemiluminescence (ECL): It produces highly efficient light emission upon application of an electrical potential, which is the basis for many analytical applications.
Its applications are vast and foundational:
Electrochemiluminescence (ECL) Immunoassays: The basis for numerous commercial clinical diagnostic systems (e.g., Roche Elecsys, Abbott ARCHITECT).
Photoredox Catalysis: One of the pioneering catalysts that helped launch the field.
Dye-Sensitized Solar Cells (DSSCs): A standard sensitizer and reference compound.
Fundamental Research: Serves as a model system for studying electron transfer, energy transfer, and excited-state dynamics.

Complex name	Tris(2,9-dimethyl-4,7-diphenyl-1,10-phenanthrolinato) ruthenium(Ⅱ) diperchlorate
CAS No.	157081-89-9
Abbreviation	$[Ru(dmdpphen)_3](ClO_4)_2$
Molecular formula/weight	$C_{78}H_{60}Cl_2RuN_6O_8$ 1381.34
Form	Powder

Structural formula



This is the perchlorate salt of the ruthenium(II) complex with the ligand bathocuproine (bcp), which is 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline. The sterically hindered methyl groups force the complex into a distorted, chiral geometry, similar to its iridium analog.

Key Property: This complex is a red-emitting luminophore. Its photophysical properties are influenced by the extended, rigid, and sterically hindered bathocuproine ligand.

⚠ CRITICAL SAFETY WARNING:

As with the previous example, this is a perchlorate salt. Salts of perchlorate with organic ligands are potentially explosive and are considered shock-sensitive, especially when dry. For this reason, the hexafluorophosphate (PF_6^-) salt is strongly preferred for safety in laboratory handling and storage.

Its primary applications are in research:

Electrochemiluminescence (ECL) studies.

As a dopant in Light-Emitting Diodes (OLEDs/LEECs).

Fundamental photophysical studies of sterically constrained ruthenium complexes