Circularly polarized luminescence (CPL) is the preferential emission of light of one circular polarization (right or left) over the other. Over the past several years, the emission of light with a preferential circular polarization has attracted considerable attention for potential applications in three-dimensional displays, photoelectric devices, biological probes, spintronic devices, optical sensors, and information storage. To date, lanthanide complexes have been the most successful at generating circularly polarized luminescence (CPL) with strong dissymmetry factors due to their luminescence arising from \( \ell \rightarrow \ell \) transitions. Because the luminescence of lanthanides is restricted by weak intrinsic absorption, sensitization of the metal center by a bound small organic molecule is often utilized in luminescence applications. Emissive chiral complexes of the lanthanides can be obtained from enantiopure ligands and even nonchiral ligands. Nevertheless, not all emissive chiral molecules can exhibit strong CPL, and knowledge about which chiral ligand moieties must be included in the ligand design. We chose to utilize the previously reported \( N,N' \)-bis(methylbipyridyl)-2,2'-bipyrrolidine (bmpbp) because bipyridines are well-known to enable lanthanide luminescence. Herein, we explore the structural and chiroptical properties of emissive lanthanide complexes supported by the bmpbp ligand. We observed strong CPL for the visible emitters (Sm, Eu, Tb, and Dy), notably for the rarer Sm and Dy complexes.

### RESULTS AND DISCUSSION

**Coordination Studies.** Scheme 1 highlights the method used to synthesize the bmpbp complexes. Acetonitrile solutions containing stoichiometric amounts of bmpbp and lanthanide(III) trifluoromethanesulfonate salts were stirred for 12 h, and the corresponding complexes were obtained as colorless crystals after concentration in vacuo followed by recrystallization by vapor diffusion of diethyl ether into the reaction mixture, often in near-quantitative yield. The display CPL with strong dissymmetry factors, including for the rarer Sm and Dy complexes.

Because the 2,2'-bipyridine scaffold does not possess any chromophore suitable for achieving sensitization, other suitable moieties must be included in the ligand design. We chose to utilize the previously reported \( N,N' \)-bis(methylbipyridyl)-2,2'-bipyrrolidine (bmpbp) because bipyridines are well-known to enable lanthanide luminescence. Herein, we explore the structural and chiroptical properties of emissive lanthanide complexes supported by the bmpbp ligand. We observed strong CPL for the visible emitters (Sm, Eu, Tb, and Dy), notably for the rarer Sm and Dy.
complexes obtained were analyzed by $^1$H NMR spectroscopy, high-resolution mass spectrometry, and combustion analyses.

The $^3$H NMR spectrum of the diamagnetic complex ((S,S)-bmpbp)Y(OTf)$_3$ displays 13 signals whose integrals sum to 16. As 32 protons are present in the free ligand, this suggests 16 pairs of identical protons and thus a single species of $C_2$ symmetry in solution (see Figure S1). In addition, all paramagnetic complexes (bmpbp)Ln(OTf)$_3$ (Ln = Sm, Eu, Tb, or Dy) displayed at most 13 paramagnetically shifted peaks (see Figures S2–S6), in agreement with their diamagnetic congener.

High-resolution mass spectra were recorded from solutions in acetonitrile for the ((R,R)-bmpbp)Ln(OTf)$_3$ complexes containing Ln = Sm, Eu, Tb, or Dy. In all spectra, a peak corresponding to [M − OTf + H]$^+$ was detected, where M is the calculated mass for a complex with a 1:1 metal:ligand ratio. Combustion elemental analyses were performed for these four complexes as well as their analogues four containing the (S,S)-bmpbp enantiomer and were found to be consistent with the calculated value for the 1:1 complex.

To further elucidate the solid-state geometry of the complexes, single crystals of the ((R,R)-bmpbp)Tb(OTf)$_3$ were grown by slow diffusion of diethyl ether into a concentrated acetonitrile solution. Although disordered, X-ray diffraction studies performed on these crystals showed an eight-coordinate terbium ion bound by the (R,R)-bmpbp ligand and two inner-sphere trifluoromethanesulfonate anions. The complex, shown in Figure 1, crystallized as a single enantiomer in the noncentrosymmetric $P2_12_12$ space group. The coordination polyhedron around the terbium ion can be described as a slightly distorted bisdiphenoid (dodecahedral deltahedron).

**Photophysical Studies.** Luminescence spectra of the visibly emitting lanthanides were collected from acetonitrile solutions and are shown in Figure 2. The obtained ultraviolet–visible (UV–vis) absorbance spectrum is consistent with the previously observed ligand-centered $\pi \rightarrow \pi^*$ transition of the bipyridine moieties. The presence of a slightly shifted peak in the excitation spectrum demonstrates sensitization of the lanthanide center by the chromophore’s excited state. All complexes exhibited the expected sharp emission peaks for each lanthanide. In the spectrum of the europium complex ((R,R)-bmpbp)Eu(OTf)$_3$, a sharp $^5D_0 \rightarrow ^7F_1$ transition was observed, consistent with a single emissive species of $C_2$ symmetry in solution. A sizable $^5D_0 \rightarrow ^7F_2$ transition was also observed, potentially due to a higher symmetry local geometry around the europium center. The terbium and europium complexes are highly luminescent with observed quantum yields of 32% and 16%, respectively; the samarium and dysprosium complexes have weaker luminescence with observed quantum yields of 0.47% and 0.33%, respectively. The emission intensity decay curves for all complexes could be fit to a single exponential, further confirming that only one species is emissive in solution (see Figures S11–S14). The lifetimes obtained (Sm, 3.7 μs; Eu, 1.76 ms; Tb, 2.94 ms; Dy, 7.8 μs) are similar to those of other luminescent lanthanide complexes. 

Equations 1–4

\[
\frac{1}{\tau_{\text{rad}}} = n^3 A_{\text{MD}} \left( \frac{I_{\text{tot}}}{I_{\text{MD}}} \right) \quad (1)
\]
\[
\Phi_{\text{Ln}} = \frac{\tau_{\text{obs}}}{\tau_{\text{rad}}} \quad (2)
\]
\[
\eta_{\text{sens}} = \frac{\Phi_{\text{obs}}}{\Phi_{\text{Ln}}} \quad (3)
\]
\[
\tau_{\text{obs}} = (k_{\text{rad}} + k_{\text{nr}})^{-1} \quad (4)
\]

where $\tau_{\text{rad}}$ is the radiative lifetime, $n$ is the index of refraction of the solution, $A_{\text{MD}}$ is the spontaneous emission probability of the $^5D_0 \rightarrow ^7F_1$ transition in vacuo (taken to be 14.65 s$^{-1}$), $I_{\text{tot}}$ and $I_{\text{MD}}$ are the integration values for the total spectrum and the $^5D_0 \rightarrow ^7F_1$ transition, respectively, $\Phi_{\text{Ln}}$ is the internal quantum yield, $\tau_{\text{obs}}$ is the observed radiative lifetime, $\Phi_{\text{obs}}$ is the observed quantum yield, $k_{\text{rad}}$ and $k_{\text{nr}}$ are the radiative and nonradiative decay rate constants, respectively, and $\eta_{\text{sens}}$ is the sensitization efficiency.

For the europium complex, using eq 1 and the ratio of the integration values for the $^5D_0 \rightarrow ^7F_1$ pure magnetic dipole transition (580–601 nm) versus the whole of the spectrum, the radiative lifetime of the europium complex was determined to be 3.89 ms. The reciprocal of this value subsequently affords a radiative decay rate constant of 257 s$^{-1}$. The ratio of the observed and calculated lifetimes allowed calculation of the internal quantum yield, 45.2%, according to eq 2. Using eq 3, the sensitization efficiency for the europium complex was determined to be 36.3%. Finally, using eq 4, a nonradiative decay rate constant of 311 s$^{-1}$ was also determined.

The triplet excited-state energy of the bmpbp ligand was determined to be 22200 cm$^{-1}$ by measurement of the low-temperature (77 K) phosphorescence of the analogous
Gadolinium complex ((R,R)-bmpbp)Gd(OTf)$_3$ in frozen acetonitrile and deconvolution of the spectrum into its vibrational progression using Gaussian peak fitting (see Figure S15). The triplet energy level of bmpbp is well placed to sensitize the emissive levels of all four of the visibly emissive lanthanides.

Circularly polarized luminescence spectra measured from acetonitrile solutions of both enantiomers of each emissive lanthanide complex. Emission spectra collected upon excitation at 290 nm. See also Figures S7–S10.

Figure 2. Ultraviolet−visible absorbance (dashed), excitation (dotted), and emission (solid) spectra for ((R,R)-bmpbp)Sm(OTf)$_3$ (top left), ((R,R)-bmpbp)Eu(OTf)$_3$ (top right), ((R,R)-bmpbp)Tb(OTf)$_3$ (bottom left), and ((R,R)-bmpbp)Dy(OTf)$_3$ (bottom right). Collected from 10$^{-4}$ M solutions in acetonitrile. Emission spectra collected upon excitation at 290 nm. See also Figures S7−S10.

Figure 3. Normalized CPL spectra of ((R,R)-bmpbp)Ln(OTf)$_3$ (red) and ((S,S)-bmpbp)Ln(OTf)$_3$ (blue) in acetonitrile solutions at room temperature upon excitation at 280 nm. The intensity of each transition has been normalized according to the CPL plot to reflect each peak’s relative $g_{\text{ lum }}$ values. The total luminescence is traced in the background. See Figures S16−S19 for $g_{\text{ lum }}$ plots and Figure S20 for more details about the collection conditions, such as slit widths and integration times.
lanthanide complex are shown in Figure 3. The spectra of both enantiomers of the terbiurn complexes exhibit the expected mirror image signals (Figure 3, bottom left). The strong luminescence intensity allowed measurement using a narrow band pass (2.4 nm), yielding extremely rich spectra with good resolution of the Stark levels in each luminescent transition. The max $|g_{lum}|$ for the $^4D_0 \rightarrow ^4F_9/2$ transition (549 nm). The values are reported comparable to those of other C$_2$symmetrical hexadentate CPL emitters. High dissymmetry factors were also observed for the less luminescent $^4D_0 \rightarrow ^4F_7$ transition (609–633 nm) with a $|g_{lum}|$ of 0.21 at 625 nm. The spectra of both enantiomers of the europium complexes also exhibit expected mirror image signals (Figure 3, top right). Dissymmetry factors are generally the highest for the $^4G_7/2 \rightarrow ^4H_{15/2}$ transition (549–577 nm). Lastly, CPL for the dysprosium complexes (Figure 3, bottom right) was measured, and strong dissymmetry factors (0.26 at 643 nm) were observed for the $^4F_{9/2} \rightarrow ^4H_{15/2}$ transition (640–676 nm). Individual $|g_{lum}|$ values for each transition in each lanthanide complex can be found in Table S2.

Comparatively, many examples of Eu and Tb CPL have already been reported based on a variety of supporting ligands such as β-diketonates, camphors, and various macrocycles [such as cyclen (1,4,7,10-tetraazacyclododecane) and its tetracarboxylic acid derivative DOTA, as well as the smaller triazacyclononane], among others. Typically, these complexes demonstrate CPL with $|g_{lum}|$ values between 0.1 and 0.5, though rare examples have been reported to possess $|g_{lum}|$ values as high as 1.38. Several examples of CPL active samarium complexes have been reported with $|g_{lum}|$ values of 0.03, 0.27, and 0.45, the former possessing a quantum yield and luminescence lifetime of 0.8% and 17 ± 2 µs, respectively. The strongest Sm CPL reported to date is a cesium tetrakis(3-heptafuorobutylpyrrolidine)-camphorato)Sm$^{III}$ complex, with a $|g_{lum}|$ of 1.15, but this remains the only report of this magnitude.

Table 1. Photophysical Measurements

| ((R,R)-bmpbp) Ln(OTf)$_3$ | $\phi$ (%) | $\tau_{lum}$ (µs, nm)$^5$ | $|g_{lum}|$ (nm)$^4$ |
|--------------------------|------------|--------------------------|-----------------|
| Ln = Sm                  | 0.47 ± 0.07 | 3.65 (596)               | 0.25 (577)      |
| Ln = Eu                  | 16.4 ± 0.2  | 1760 (618)               | 0.06 (592)      |
| Ln = Tb                  | 31.8 ± 0.2  | 2940 (546)               | 0.19 (543)      |
| Ln = Dy                  | 0.33 ± 0.01 | 7.75 (481)               | 0.26 (643)      |

$^4$Excitation at 270 nm. $^5$Excitation at 290 nm. $^6$Excitation at 280 nm.

Conclusions

We have synthesized and characterized lanthanide complexes supported by chiral 2,2'-bipyrdylidine-derived ligands. Using bipyridines as sensitizers, emissive complexes of samarium, europium, terbiurn, and dysprosium were obtained exhibiting luminescence with quantum yields of ≤32%. All complexes display the emission of circularly polarized luminescence with strong dissymmetry factors. Most notably, respectable dissymmetry factors are measured for all four emissive lanthanides tested, including the much less common Sm and Dy. We demonstrate here that the C$_2$symmetrical 2,2'-bipyrdylidine scaffold is suitable for the emission of strong CPL and are currently exploring other ligand derivatives with the goal of increasing both luminescence and dissymmetry factors.

Experimental Section

Materials. Lanthanide triflate salts were purchased from Alfa Aesar [Eu(OTf)$_3$, and Dy(OTf)$_3$], StremChemicals [Gd(OTf)$_3$ and Tb-(OTf)$_3$], or Oakwood Chemicals [Y(OTf)$_3$ and Sm(OTf)$_3$] and stored under an inert atmosphere but otherwise used as received. All solvents used were HPLC grade and dried using a solvent purification system from Pure Process Technology. After drying, solvents were stored under an inert atmosphere over 3 Å molecular sieves.

The bmpbp ligand was synthesized as reported previously.13,16 Instrumentation. $^1$H NMR spectra recorded on a 400 MHz Bruker Avance III spectrometer using the TopSpin suite of software; the spectra were processed using the Mestrelab MNova software suite. Chemical shifts are reported in parts per million and were determined relative to the residual solvent signal (1.94 ppm for acetonitrile). In Figures S1–S6, peak locations in parts per million are reported along the top while integration values are shown along the bottom, where possible. Abbreviations are as follows: s, singlet; d, doublet; t, triplet; br. s, broad singlet.

All photophysical measurements were recorded from solutions of noted concentration in dry, degassed anisotriol. Solution preparation was performed inside a glovebox with ambient oxygen and water levels constantly below 2 ppm.

Quantum yield measurements were recorded for ((S,S)-bmpbp)-Eu(OTf)$_3$ and ((S,S)-bmpbp)-Tb(OTf)$_3$, from 10$^{-6}$ M solutions using a Horiba FluorologMax spectrophotometer equipped with an integrating sphere and the FluorEssence suite of software. For ((S,S)-bmpbp)-Sm(OTf)$_3$ and ((S,S)-bmpbp)-Dy(OTf)$_3$, quantum yield measurements were recorded using the relative method from 10$^{-5}$ M stock solutions in anisotriol, and subsequent dilutions thereof, using a Horiba Duetta spectrophotometer. 9,10-Diphenylanthracene was used as a reference ($\phi = 0.86$ in cyclohexane, excitation at 270 nm). The values are reported ± the absolute error.

Lifetime measurements recorded from 10$^{-6}$ M for ((R,R)-bmpbp)-Tb(OTf)$_3$, 10$^{-5}$ M for ((R,R)-bmpbp)Eu(OTf)$_3$, or 10$^{-4}$ M for ((R,R)-bmpbp)Sm(OTf)$_3$ and ((R,R)-bmpbp)-Dy(OTf)$_3$, using an OLIS CPL Slow spectrophotometer. Spectra were collected using pulsed excitation at 280 nm and time-resolved emission measurements fixed at the peak of strongest emission.
Excitation and emission slit widths were fixed at 3.16 mm. A first-order exponential decay curve was fit to the collected data to estimate the fluorescence lifetime ($\tau_{flu}$). Values are reported as measured lifetimes (observation wavelength).

CPL spectra and subsequently derived $g_{colum}$ values were recorded using an OLIS CPL Solo spectrophotometer and the globalworks software suite. The emission peak with the strongest CPL is reported as $g_{colum}$ (wavelength). Collection conditions are summarized in Figure S20.

Single-crystal X-ray diffraction studies were performed at Vanderbilt University. A suitable crystal of each sample was selected using direct methods and refined with the ShelXL refinement package using least-squares minimization.

**General Procedure for the Synthesis of bmpbp-Supported Lanthanide Complexes.** Complexes were prepared in a glovebox under a nitrogen atmosphere with ambient water and oxygen levels constantly below 2 ppm.

To a 20 mL scintillation vial was added Ln(OTf)₃ salt as well as 5 mL of acetonitrile and a magnetic stir bar. In a second vial, a stoichiometric quantity of bmpbp was measured by mass and subsequently dissolved in an additional 8 mL of acetonitrile. When the mixture was being stirred, the solution of the ligand was added dropwise to the solution of metal over 10 min. The resulting solution was then allowed to stir at room temperature for 12 h. The reaction mixture was then reduced to a small volume in vacuo, followed by reconstitution in a minimum amount of acetonitrile. This solution was then transferred to a smaller vial and subjected to vapor diffusion of diethyl ether at room temperature. Once crystallized, the mother liquor was siphoned off and the crystals were dried over 3 days.

**((S,S)-bmpbp)Y(OTf)₃.** Produced according to the general procedure utilizing 23 mg of Y(OTf)₃ (42 μmol) and 20 mg of (S,S)-bmpbp (43 μmol, 1.0 equiv). Yield: 39 mg (91%) of a colorless solid. ¹H NMR (400 MHz, acetonitrile-d₃): δ 9.10 (s, 2H), 8.45 (d, J = 8.1 Hz, 2H), 8.31 (t, J = 7.8 Hz, 4H), 7.77 (br. s, 2H), 7.70 (d, J = 7.8 Hz, 2H), 4.25 (s, 4H), 3.04 (s, 2H), 2.27 (br. s, 2H), 2.01 (br. s, 4H), 1.80 (br. s, 2H), 1.54 (br. s, 2H), 1.30 (br. s, 2H).

**((R,R)-bmpbp)Sm(OTf)₃.** Produced according to the general procedure utilizing 13 mg of Sm(OTf)₃ (21 μmol) and 10 mg of (R,R)-bmpbp (22 μmol, 1.0 equiv). Yield: 22 mg (96%) of a colorless solid. ¹H NMR (400 MHz, acetonitrile-d₃): δ 8.95 (d, J = 7.9 Hz, 2H), 8.31 (br. s, 2H), 7.52 (br. s, 4H), 6.70 (br. s, 2H), 2.71 (br. s, 2H), 2.33 (br. s, 2H), 1.61 (br. s, 2H), 1.27 (s, 2H), –0.73 (br. s, 4H). HRMS: m/z calc for [Sm(bmpbp)OTf₂ + H]+ 926.0920, found 926.0892. Elemental Anal. Calcld (%): C, 36.90; H, 2.99; N, 7.82. Found (%): C, 36.95; H, 2.99; N, 7.85.

**((S,S)-bmpbp)Eu(OTf)₃.** Produced according to the general procedure utilizing 25 mg of Eu(OTf)₃ (42 μmol) and 20 mg of (S,S)-bmpbp (42 μmol, 1.0 equiv). Yield: 45 mg (96%) of a colorless solid. ¹H NMR (400 MHz, acetonitrile-d₃): δ 8.90 (t, J = 7.9 Hz, 2H), 8.34 (br. s, 2H), 7.56 (br. s, 4H), 6.76 (br. s, 2H), 2.72 (br. s, 2H), 2.34 (br. s, 2H), 1.64 (br. s, 2H), 1.31 (s, 2H), –0.70 (br. s, 4H). Elemental Anal. Calcld (%): C, 36.90; H, 3.00; N, 7.82. Found (%): C, 36.95; H, 2.98; N, 7.86.

**((R,R)-bmpbp)Tb(OTf)₃.** Produced according to the general procedure utilizing 13 mg of Tb(OTf)₃ (21 μmol) and 10 mg of (R,R)-bmpbp (22 μmol, 1.0 equiv). Yield: 46 mg (quant) of a colorless solid. ¹H NMR (400 MHz, acetonitrile-d₃): δ 138.98, 120.63, 59.97, 55.55, 30.28, 27.02, 25.16, 15.2, 12.6, –27.71, –43.62, –76.53, –176.50. Due to paramagnetic effects, all peaks appear to be broad and cannot be accurately integrated. HRMS: m/z calc for [Tb(bmpbp)OTf₂ + H]+ 938.0977, found 938.0812. Elemental Anal. Calcld (%): C, 36.61; H, 2.98; N, 7.76. Found (%): C, 36.68; H, 2.88; N, 7.69.

**((S,S)-bmpbp)Tb(OTf)₃.** Produced according to the general procedure utilizing 26 mg of Tb(OTf)₃ (43 μmol) and 20 mg of (S,S)-bmpbp (42 μmol, 1.0 equiv). Yield: 47 mg (quant) of a colorless solid. ¹H NMR (400 MHz, acetonitrile-d₃): δ 183.11, 149.12, 129.52, 87.82, 65.13, 33.55, 8.42, –10.03, –14.41, –23.78, –74.72, –174.85. Due to paramagnetic effects, all peaks appear to be broad and cannot be accurately integrated. HRMS: m/z calc for [Eu(bmpbp)OTf₂ + H]+ 938.1019, found 938.0812. Elemental Anal. Calcld (%): C, 36.49; H, 2.97; N, 7.74. Found (%): C, 36.44; H, 2.92; N, 7.70.

**((R,R)-bmpbp)Dy(OTf)₃.** Produced according to the general procedure utilizing 13 mg of Dy(OTf)₃ (21 μmol) and 10 mg of (R,R)-bmpbp (22 μmol, 1.0 equiv). Yield: 20 mg (87%) of a colorless solid. ¹H NMR (400 MHz, acetonitrile-d₃): δ 149.22, 138.98, 120.63, 59.97, 55.55, 30.28, 27.02, 25.16, 15.2, 12.6, –27.71, –43.62, –76.53, –176.65. Due to paramagnetic effects, all peaks appear to be broad and cannot be accurately integrated. Elemental Anal. Calcld (%): C, 36.61; H, 2.98; N, 7.76. Found (%): C, 36.70; H, 2.87; N, 7.74.

**((R,R)-bmpbp)Tb(OTf)₃.** Produced according to the general procedure utilizing 13 mg of Tb(OTf)₃ (21 μmol) and 10 mg of (R,R)-bmpbp (22 μmol, 1.0 equiv). Yield: 46 mg (quant) of a colorless solid. ¹H NMR (400 MHz, acetonitrile-d₃): δ 183.99, 149.73, 130.76, 87.77, 64.73, 33.85, 8.18, –10.47, –14.54, –24.19, –74.73, –175.65, –254.56. Due to paramagnetic effects, all peaks appear to be broad and cannot be accurately integrated. Elemental Anal. Calcld (%): C, 36.49; H, 2.97; N, 7.74. Found (%): C, 36.47; H, 2.98; N, 7.75.

**ASSOCIATED CONTENT**

**Supporting Information**

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.inorgchem.0c00946

**Spectroscopic data and crystallographic parameters**

**Accession Codes**

CCDC 1991731 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge via www.ccdc.cam.ac.uk/data_request/cif, or by emailing data_request@ccdc.cam.ac.uk, or by contacting The Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44 1223 336033.
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Notes
The authors declare no competing financial interest.

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Abbreviations

OTf, triflate ion (CF3SO3-); bmpbp, N,N’-bis-(methylbipyridyl)-2,2’-bipyrrolidine

References


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