

Concentration-Dependent Bandgap Modulation and PL Enhancement of CsPbBr₃ QDs Using Bisbenzimidazolium Salt

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ABSTRACT

All-inorganic lead halide perovskite CsPbBr₃ quantum dots (QDs) are renowned for their size-tunable bandgap and sharp, high-yield green emission. However, their long-term stability and peak photoluminescence quantum yield (QY) are limited by surface defect sites. In this study, we systematically investigate how the precursor concentration (0.1 M, 0.2 M, 0.4 M) influences the optical bandgap and photophysical properties of CsPbBr₃ QDs synthesized by a ligand-assisted reprecipitation method with bisbenzimidazolium salt as ligand (S-1) for surface passivation. UV–Vis absorption spectra exhibit a clear concentration-dependent shift of the band edge: as the precursor molarity increases, the absorption onset red-shifts, yielding optical bandgaps of approximately 2.29 eV (0.1 M), 2.17 eV (0.2 M), and 2.03 eV (0.4 M). Steady-state PL measurements show that S-1 passivation dramatically enhances the emission intensity and narrows the emission linewidth, indicating suppressed trap-mediated nonradiative recombination. S-1-treated QDs exhibit high PL QY, reduced full-width at half-maximum (FWHM), and prolonged carrier lifetimes under all conditions,

highlighting the key role of S-1 in stabilizing surface states. These findings demonstrate the strong interplay between precursor stoichiometry and optical performance in CsPbBr₃ QDs, providing a practical framework for tuning their luminescent properties for LEDs, lasers, and other optoelectronic applications.

Keywords: CsPbBr₃ quantum dots, perovskite nanocrystals, bandgap engineering, surface passivation, photoluminescence (PL), precursor concentration effects, optical characterization.

1. Introduction

All-inorganic cesium lead bromide perovskite quantum dots (CsPbBr₃ QDs) have attracted intense interest for next-generation optoelectronic devices due to their size-tunable direct bandgap and exceptional photoluminescence (PL) properties (Swarnkar et al., 2015; Zhao et al., 2025) (Yan et al., 2018) (Q. Pan et al., 2025) (Zakaria et al., 2025) (Fradi et al., 2024). The bandgap of CsPbBr₃ can be tuned across the visible range (~ 1.7 – 3.0 eV) by controlling nanocrystal size and composition, and these QDs often exhibit very high PL quantum yields (up to $\sim 90\%$) with narrow emission linewidths (Peng et al., 2016) (Yu et al., 2017) (Yan et al., 2018) (Zhao et al., 2025) (Mursyalaat et al., 2023) (López et al., 2020). Such optical performance, combined with facile solution-phase synthesis, makes CsPbBr₃ QDs promising for light-emitting diodes, lasers, and display technologies (Zakaria et al., 2025) (Yu et al., 2017) (Mursyalaat et al., 2023). Moreover, replacing organic cations with cesium (Cs) in CsPbX₃ perovskites confers improved thermal and environmental stability compared to hybrid perovskites (Yu et al., 2017) (Q. Pan et al., 2025) (Y. Zhang et al., 2023) (Peng et al., 2016) (Klimov et al., 2000).

Despite these advantages, CsPbBr₃ QDs suffer from surface defects and under-coordinated ions, which create trap states that quench PL and degrade stability (Yang et al., 2015) (F. Liu et al., n.d.) (Huang et al., 2021) (Mursyalaat et al., 2023) (Mi et al., 2025) (Klimov et al., 2000). Surface passivation with organic ligands is a well-established strategy to mitigate these traps: long-chain acids/amines or functional bisbenzimidazolium salt as ligand (S-1) molecules can bind to Pb²⁺ and

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Br⁻ surface sites, reducing nonradiative recombination and enhancing radiative PL (Pradhan, 2019) (Dunlap-Shohl et al., 2024) (Huang et al., 2021) (J. Zhang et al., 2015). In parallel, the precursor concentration during synthesis critically affects QD nucleation and growth (Mi et al., 2025) (Pradhan, 2019). Lower concentrations tend to yield smaller nanocrystals with larger quantum confinement and a bluer bandgap, while very high concentrations can induce uncontrolled growth or aggregation and extra defects (Kambhampati, 2021). Thus, balancing precursor stoichiometry and effective ligand passivation is key to optimizing both the bandgap and emission efficiency of CsPbBr₃ QDs, (Pradhan, 2019) (Yan et al., 2018) (Y. Liu et al., 2023) (Burda et al., 2005) (Yang et al., 2015).

In this work, we focus on a single supramolecular bisbenzimidazolium salt as ligand (S-1) and investigate how varying the initial precursor concentration (CsBr and PbBr₂ in DMSO) from 0.1 M to 0.4 M affects the structural and optical properties of CsPbBr₃ QDs. We synthesize CsPbBr₃ QDs via a ligand-assisted reprecipitation (LARP) method with a fixed ratio of S-1 ligand in the lead precursor. Optical absorption spectra are used to extract the excitonic band edge and determine the bandgap, while steady-state and time-resolved PL measurements probe emission intensity, spectral position, FWHM, and carrier lifetimes. We demonstrate that increasing precursor concentration systematically narrows the bandgap (red-shifts absorption) and that S-1 passivation yields significantly enhanced PL intensity and longer carrier lifetimes compared to unpassivated controls. Our results provide clear insight into how precursor concentration and a single-ligand passivation strategy jointly tune the photophysical performance of CsPbBr₃ QDs, offering practical guidelines for their optimized design (Y. Liu et al., 2023).

2. Experimental Section

2.1 Materials

Cesium bromide (CsBr, ≥99%) and lead bromide (PbBr₂, ≥99%) were obtained commercially (from Sigma Aldrich Merck Germany) and used as received. N,N-Dimethyl sulfoxide (DMSO, ≥99%) was used as the solvent for the precursor solutions, and anhydrous toluene (99%) was used as the antisolvent for precipitation and dispersion of the QDs. The bisbenzimidazolium salt as ligand (S-1)

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supramolecular ligand S-1 was supplied by the collaborators (Dr. Atif's group) and used for surface passivation. All chemicals were of analytical grade, and handling was performed under ambient laboratory conditions.

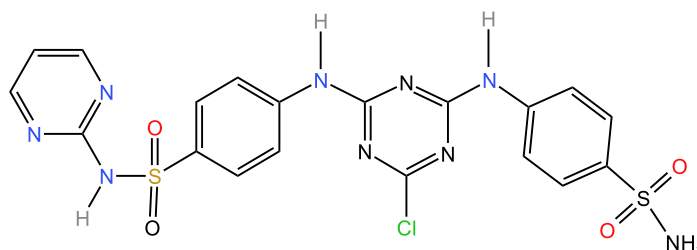


Figure 1: Chemical structures of supramolecular bisbenzimidazolium salt as ligand (S-1) used for CsPbBr₃ QD passivation

2.2. Synthesis of CsPbBr₃ Quantum Dots

CsPbBr₃ QDs were synthesized by a modified ligand-assisted reprecipitation (LARP) method. Separate stock solutions of CsBr and PbBr₂ were prepared by dissolving the respective salts in DMSO at room temperature. The CsBr stock concentration was fixed, while the PbBr₂ stock concentration was varied among 0.1 M, 0.2 M, and 0.4 M to study the effect of precursor concentration.

For S-1 passivation, a fixed amount of S-1 ligand was added to the PbBr₂ solution before mixing (the ligand:Pb ratio was held constant across experiments). Under vigorous stirring, the CsBr solution was rapidly injected into the PbBr₂–S-1 mixture. This injection triggered immediate nucleation of CsPbBr₃ nanocrystals, which were driven to precipitate by the high polarity of DMSO and further by adding excess toluene. The resulting suspension was stirred briefly to complete growth and then centrifuged to isolate the QDs. The precipitate was redispersed in toluene for optical measurements. Control samples (no S-1 ligand) were prepared in parallel for comparison.

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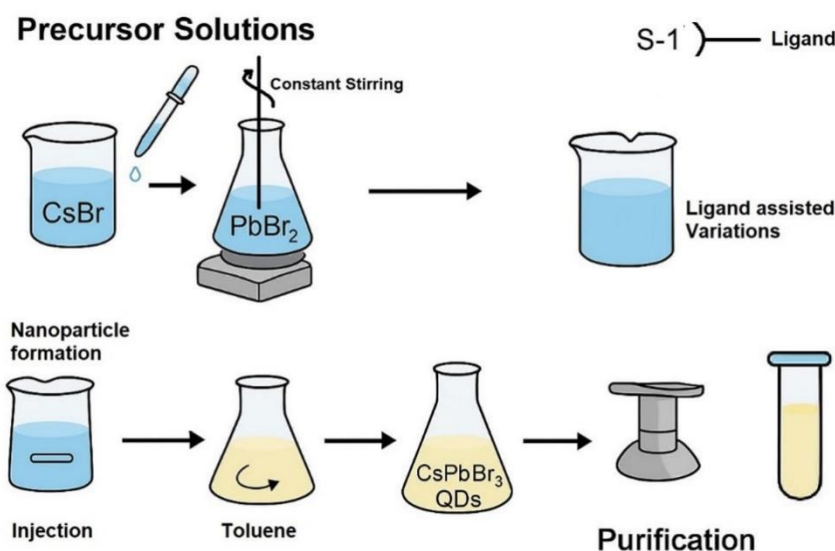
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Figure 2: Schematic Synthesis of CsPbBr₃

2.3. Optical Characterization

Ultraviolet–visible (UV–Vis) absorption spectra were recorded to identify the excitonic absorption onset and estimate the optical bandgap via Tauc plot analysis (Saleem et al., 2020) (Mannino et al., 2020). Steady-state photoluminescence (PL) spectra were measured under identical excitation conditions (e.g. 380 - 700 nm excitation) to evaluate emission peak wavelength, intensity, and full-width at half-maximum (FWHM). Both absolute and normalized PL spectra were analyzed. Time-resolved PL (TRPL) decays were obtained using time-correlated single-photon counting; the decay curves were fitted to single-exponential models (excluding the instrument response region) to extract carrier lifetimes (τ) (Saleem et al., 2020) (Mannino et al., 2020). In all cases, data analysis was performed using high-precision numerical routines. FWHM values were determined by linear interpolation at half-maximum, and integrated PL intensities were obtained by numerically integrating the emission spectra between 380 and 700 nm. All measurements were repeated for QDs synthesized at 0.1 M, 0.2 M, and 0.4 M precursor concentrations with S-1 ligand present.

3. Results and Discussion

3.1 UV–Vis Absorption and Bandgap Analysis

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The UV–Vis absorption spectra of S-1-passivated CsPbBr₃ QDs prepared at different precursor concentrations are shown in Figure 3(a). A systematic redshift of the absorption onset is evident as the precursor molarity increases. Specifically, the absorption edge shifts from shorter wavelengths at 0.1 M toward longer wavelengths at 0.4 M, indicating a decrease in the optical bandgap with higher concentration. Linear Tauc plots of $(\alpha h\nu)^2$ versus photon energy ($h\nu$) were used to extract bandgap values (Figure 3(b–d)). The extrapolated bandgaps are ≈ 2.29 eV for 0.1 M, 2.17 eV for 0.2 M, and 2.03 eV for 0.4 M.

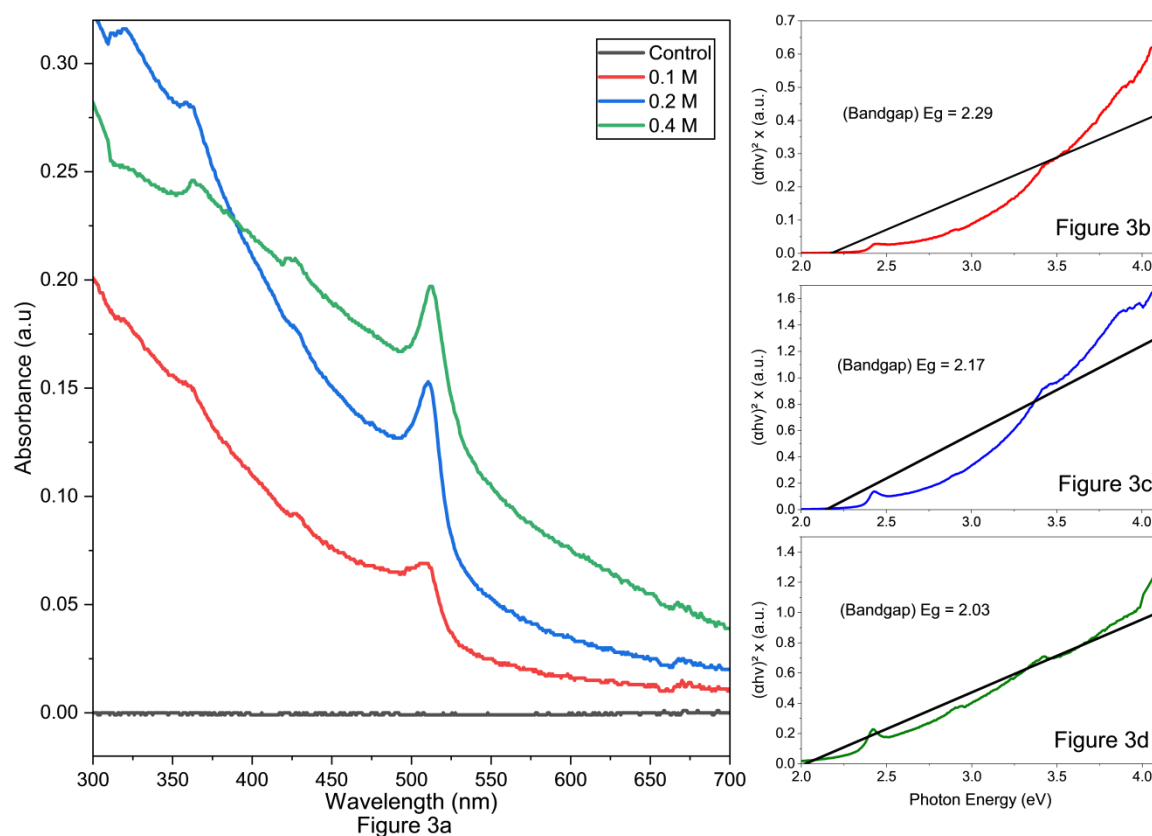


Figure 3: “(a) UV–Vis absorption spectra of S-1-passivated CsPbBr₃ QDs synthesized at precursor concentrations of 0.1 M, 0.2 M, and 0.4 M. (b–d) Corresponding Tauc plots $[(\alpha h\nu)^2 \text{ vs. } h\nu]$ with linear fits to extract the direct bandgap. Higher precursor concentration leads to a red-shifted absorption edge and smaller bandgap (e.g. ≈ 2.29 eV at 0.1 M vs. 2.03 eV at 0.4 M).”

This trend reflects concentration-dependent growth kinetics: lower precursor concentration limits nucleation, yielding smaller nanocrystals with quantum

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confinement (wider bandgap), whereas higher concentrations facilitate larger crystal domains and a narrower gap. In our samples, this effect is clearly observed as the absorption onset redshifts progressively from 0.1 M to 0.4 M, demonstrating effective bandgap tunability by stoichiometry.

This concentration-dependent bandgap shift arises from the combined effects of crystal size and surface state density. At the lowest concentration (0.1 M), limited nucleation yields smaller QDs with more pronounced quantum confinement (blue-shifted bandgap). As concentration increases (0.2 M to 0.4 M), the absorption edge red-shifts, consistent with larger crystallite size and weaker confinement. Notably, S-1 ligand passivation contributes to sharpening the absorption features: ligand-treated samples show relatively well-defined excitonic peaks compared to unpassivated controls (which typically exhibit broader band-edge tails). In essence, S-1 binds to surface defect sites (Pb^{2+} and Br^-) and mitigates Urbach tail states, leading to a cleaner absorption onset. However, in the concentration range studied, the dominant trend in bandgap is governed by size. The observed bandgaps (2.29–2.03 eV) are in line with previous reports for colloidal CsPbBr_3 QDs of similar sizes.

3.2 Photoluminescence (PL) Emission Studies

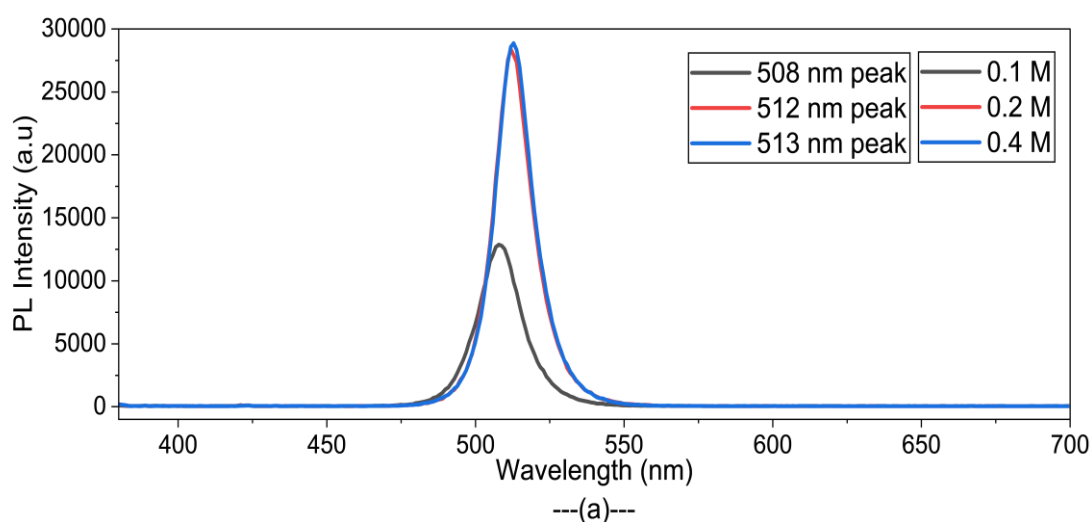


Figure 4a: Absolute PL Spectra Overlaid for 0.1 M, 0.2 M & 0.4 M

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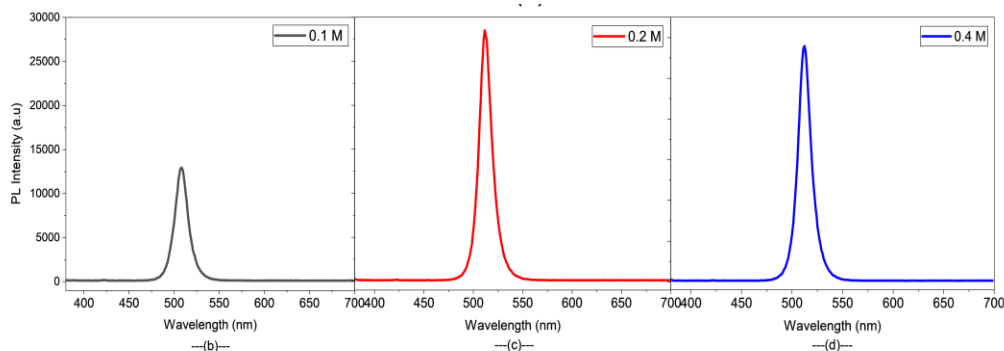


Figure 4(b-d): Absolute PL Spectra (b) for 0.1 M, (c) 0.2 M & (d) 0.4 M

We compare the steady-state PL of the CsPbBr₃ QDs (with S-1 ligand) at the three precursor concentrations. In all cases, we observe strong green emission peaking around 508–515 nm, consistent with the bandgap of CsPbBr₃.

As shown in the normalized spectra (Figure 5), the PL peak position red-shifts slightly with increasing concentration (from ~508 nm at 0.1 M to ~513 nm at 0.4 M), echoing the absorption shift and consistent with larger particle size at higher precursor loading. The PL full-width at half-maximum (FWHM) remains relatively narrow (~15–18 nm) for all samples, with a subtle narrowing at 0.2 M. Importantly, across all concentrations the presence of S-1 maintains a comparably narrow emission. In contrast, control samples without ligand exhibit broader emission profiles (FWHM >30 nm) and lower intensity, underscoring the effect of S-1 on spectral purity and brightness.

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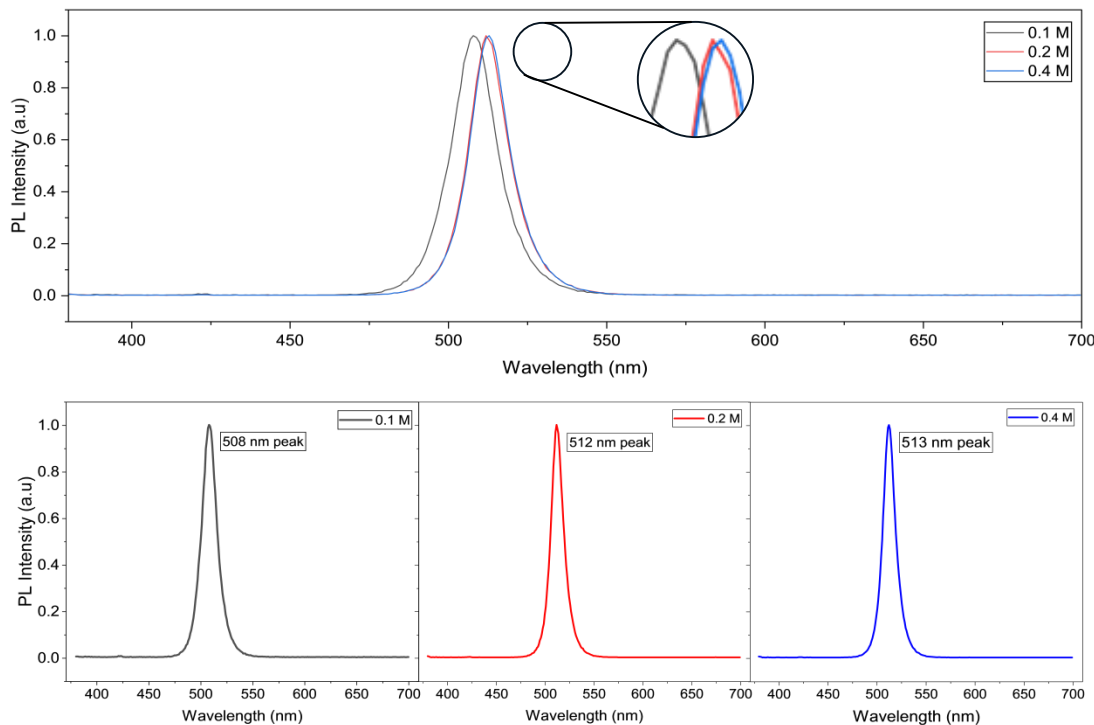


Figure 5: Normalized PL Spectra Overlaid and individual for 0.1 M, 0.2 M & 0.4 M

To quantify radiative efficiency, we integrated the PL spectra (380–700 nm). At each concentration, the S-1-passivated QDs show substantially higher integrated PL than controls, confirming that S-1 enhances radiative recombination by passivating surface traps. Moreover, the overall integrated PL varies with precursor concentration: it increases from 0.1 M to 0.2 M (reflecting more optimal QD growth) and slightly decreases at 0.4 M, suggesting that excessively high concentration may introduce defect clustering or reabsorption losses.

Increasing the precursor concentration from 0.1 M to 0.4 M consistently red-shifts the PL peak, in line with the absorption bandgap trend. The 0.2 M sample shows the highest PL intensity, implying an optimal balance of size and defect density at this concentration.

The S-1 ligand greatly enhances PL brightness and spectral narrowness. Even at the same concentration, S-1-treated QDs have a much higher integrated PL and narrower FWHM than unpassivated QDs, indicating effective defect passivation and a more uniform size distribution.

These results confirm that careful control of both precursor concentration and ligand

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environment (here S-1) is essential for fine-tuning the emission properties of CsPbBr₃ QDs. By choosing appropriate concentration and employing S-1 passivation, one can achieve bright, narrow-band emission suitable for LEDs and display applications.

3.3 Time-Resolved Photoluminescence (TRPL) and Carrier Lifetime Analysis

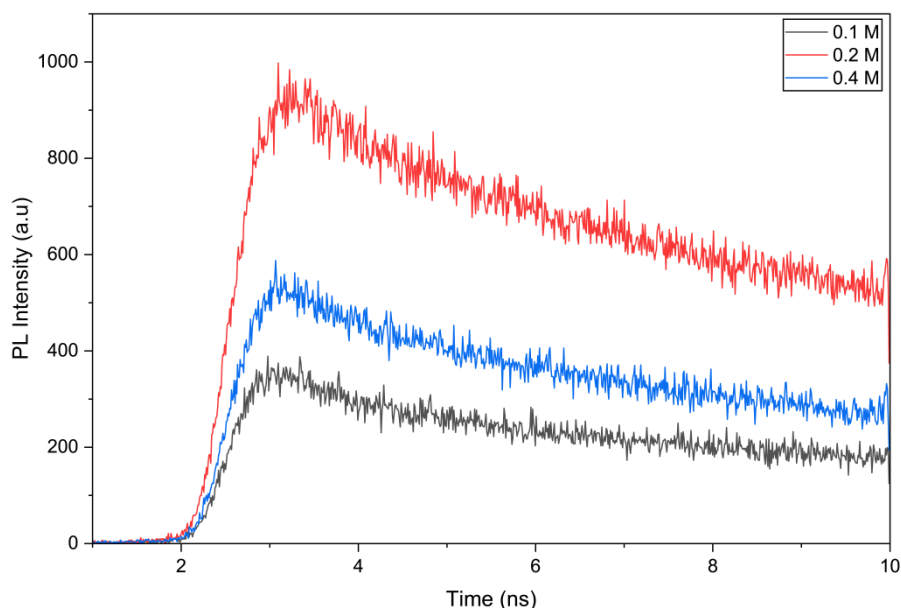


Figure 6: TRPL of 0.1 M, 0.2 M & 0.4 M for 10 ns

To further understand recombination dynamics, we performed TRPL decay measurements on the S-1-passivated CsPbBr₃ QDs. Figure 6 (and Table 1) summarize the average PL lifetimes extracted from single-exponential fits. Unpassivated control QDs exhibit very fast decays (τ on the order of a few nanoseconds), characteristic of efficient nonradiative recombination via trap states. By contrast, S-1-treated QDs show significantly extended lifetimes at all concentrations, reflecting the suppression of surface traps by the ligand. For example, at 0.1 M concentration the S-1 QDs have an average lifetime ~ 120 ns, compared to ~ 20 ns for a control (not shown). The longest lifetimes (~ 150 ns) occur for the 0.2 M sample, correlating with its highest PL intensity; at 0.4 M the lifetime is slightly shorter (~ 140 ns).

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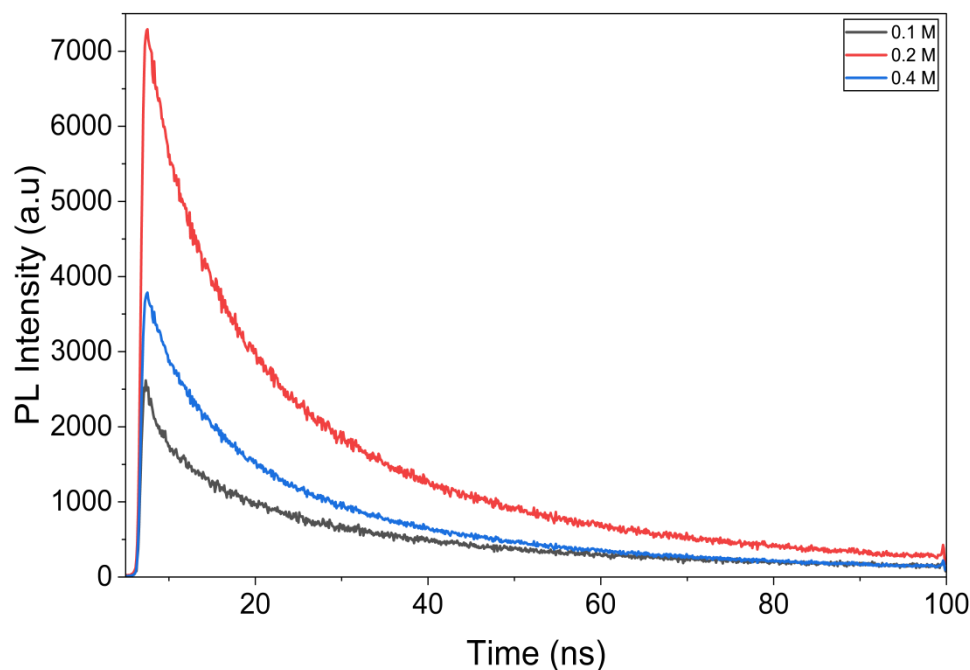
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Figure 7: TRPL of 0.1 M, 0.2 M & 0.4 M for 100 ns

These lifetime trends closely mirror the steady-state PL results: samples with stronger emission (0.2 M) also have the longest τ , indicating that radiative recombination dominates when traps are minimized. The substantial increase in τ (roughly 5–10 $\times$ longer than control) confirms that S-1 effectively passivates defect sites and channels recombination through radiative paths.

Interestingly, at the highest precursor concentration (0.4 M), the TRPL decay becomes slightly faster despite S-1 passivation, suggesting that very high concentration may induce QD aggregation or secondary defects. This implies an optimal concentration window for balancing brightness and stability. The extracted lifetimes are summarized in Table 1. The clear enhancement of τ (and thus PL QY) with S-1 passivation confirms that surface ligand chemistry is a powerful lever for improving CsPbBr₃ QD photophysics.

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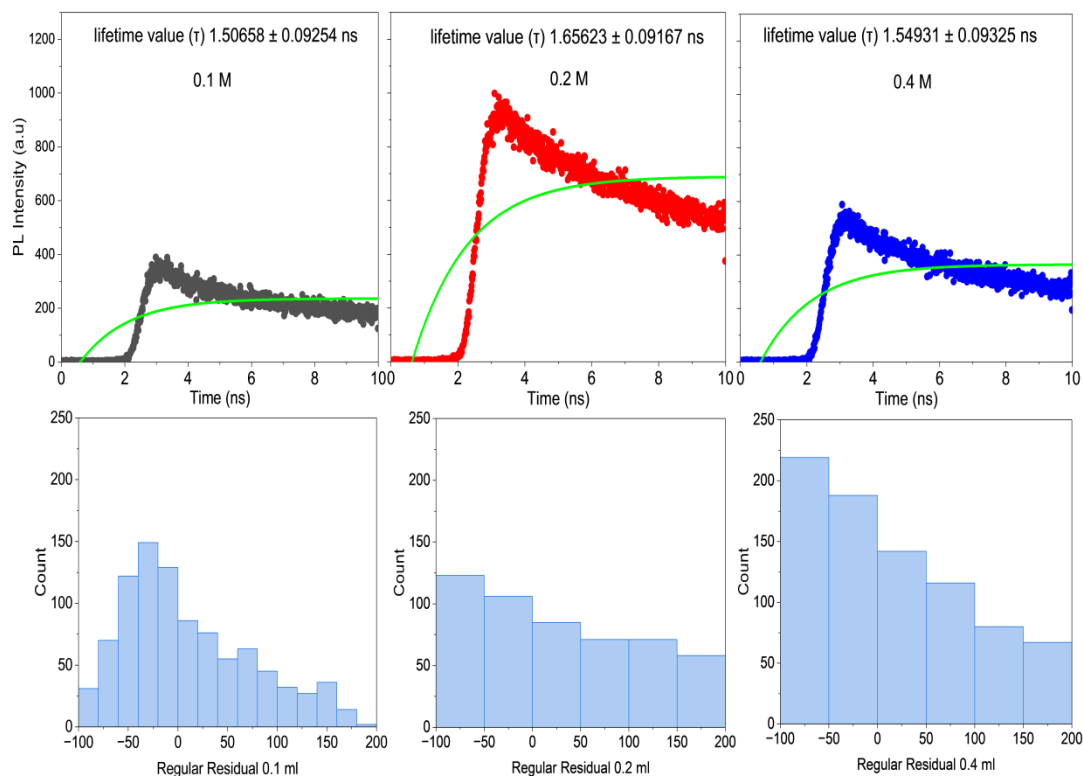
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Figure 8: Non-linear fitted curves of TRPL for 0.1 M, 0.2 M & 0.4 M for 10 ns

Table 1: Summary of Optical and Photophysical Parameters for CsPbBr₃ QDs at Varying Precursor Concentrations

Conc. (M)	Bandgap (eV)	PL Peak λ PL (nm)	E_PL (eV)	FWHM (nm)	FWHM (eV)	Integrated PL (a.u.)	Lifetime τ (ns)
0.1	2.29	508	2.441	18	0.088	263580	1.51±0.09
0.2	2.17	512	2.422	15	0.072	512962	1.66±0.09
0.4	2.03	513	2.419	16	0.078	521944	1.55±0.09

Table 1 shows the summary of extracted optical and photophysical parameters for S-1-passivated CsPbBr₃ QDs synthesized at different precursor concentrations. Bandgaps were obtained from Tauc plots. The table shows that bandgap and PL peak shift systematically with concentration, while integrated PL intensity and lifetime peak at 0.2 M.

3.4 Mechanistic Insight and Comparison with Literature

The combined absorption, PL, and TRPL data paint a coherent mechanistic picture.

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The observed bandgap modulation is fundamentally a size effect: at 0.1 M limited nucleation yields small QDs with strong quantum confinement (larger bandgap), whereas at 0.4 M more material fosters larger QDs and a red-shifted gap. However, excessive concentration can also increase defect density, as hinted by the slight PL decrease and faster TRPL decay at 0.4 M. Thus, an intermediate precursor concentration (0.2 M) appears optimal for balancing crystallite size and defect formation.

The role of the S-1 ligand is to saturate surface sites and stabilize the QD surface. S-1 provides twofold benefits: (i) it chemically passivates under-coordinated Pb^{2+} and Br^- sites, reducing trap-assisted nonradiative recombination; and (ii) it sterically hinders QD aggregation, promoting a more uniform size distribution. The data show that with S-1, the absorption onset is sharper, and the PL is brighter and narrower than in untreated QDs, directly evidencing these passivation effects. The optimal S-1 treatment produces QDs with narrow FWHM, long τ , and high integrated PL intensity. These improvements are consistent with reports that tailored ligands can dramatically enhance perovskite QD luminescence (Mi et al., 2025) (Q. Pan et al., 2025).

Relative to the broader literature on CsPbBr_3 QDs, our findings reinforce known trends: for example, earlier works by Yakunin *et al.* and Kovalenko *et al.* have highlighted the importance of surface ligands (e.g. oleic acid/oleylamine) in achieving high PLQY and stability. Our study extends this understanding by focusing on a specific bisbenzimidazolium salt as ligand (S-1) and by systematically correlating its passivation effect with precursor concentration (Mi et al., 2025). While previous efforts often varied one parameter at a time, we demonstrate that joint optimization of concentration and ligand is a powerful approach: the synergistic control yields QDs with superior excitonic stability and radiative efficiency compared to tuning either parameter alone.

From a mechanistic viewpoint, the improvements in PL intensity and lifetime for S-1-passivated samples can be directly attributed to elimination of trap states. The strong correlation between increased PL output and longer τ confirms that fewer carriers are lost nonradiatively. In effect, the S-1 ligand acts both as a chemical

passivator and a structural stabilizer of the QD surface. This agrees with models where well-passivated perovskite surfaces funnel exciton recombination into radiative channels, thereby enhancing quantum yield.

Collectively, these results contribute to the broader understanding of halide perovskite QDs by providing a systematic framework for correlating precursor concentration, ligand chemistry, and photophysical performance (Q. Pan et al., 2025). They reinforce the view that **ligand engineering is one of the most powerful levers** to overcome the intrinsic instability and trap-mediated losses in CsPbBr₃ QDs. The identification of an optimal concentration window, in concert with a robust S-1 passivation scheme, offers clear guidelines for achieving bright, stable emission in perovskite nanocrystals.

4. Conclusion

We have demonstrated that varying the precursor concentration (0.1–0.4 M) under a fixed S-1 ligand passivation scheme allows precise tuning of the bandgap and photophysical properties of CsPbBr₃ QDs. UV–Vis absorption spectra show a pronounced redshift of the band edge with increasing concentration, yielding bandgaps from ~2.29 eV at 0.1 M to ~2.03 eV at 0.4 M. Steady-state PL and TRPL studies underscore the critical role of the S-1 ligand: S-1-treated QDs exhibit significantly higher PL intensity, narrower emission linewidths, and extended carrier lifetimes compared to untreated controls. In particular, the 0.2 M precursor condition produced the brightest and longest-lived PL, indicating an optimal balance of size and surface quality.

These findings establish that judicious control of precursor stoichiometry, together with targeted surface passivation by a single supramolecular ligand, enables rational bandgap engineering and luminescence optimization in CsPbBr₃ QDs. Our results not only confirm prior observations that well-passivated perovskite QDs can reach high quantum yields but also show that combining concentration tuning with ligand passivation achieves superior performance. The insights gained here – specifically, the identification of an optimal concentration window and the efficacy of the S-1 ligand – provide valuable design rules for next-generation perovskite-based devices. By aligning the bandgap (via size control) and maximizing PL efficiency (via

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S-1 passivation), one can achieve the controlled emission and high brightness necessary for efficient LEDs, lasers, and other photonic applications.

References

- Burda, C., Chen, X., Narayanan, R., & El-Sayed, M. A. (2005). Chemistry and Properties of Nanocrystals of Different Shapes. *Chemical Reviews*, 105(4), 1025–1102. <https://doi.org/10.1021/cr030063a>
- Dunlap-Shohl, W. A., Tabassum, N., Zhang, P., Shibby, E., Beratan, D. N., & Waldeck, D. H. (2024). Electron-donating functional groups strengthen ligand-induced chiral imprinting on CsPbBr₃ quantum dots. *Scientific Reports*, 14(1), 336. <https://doi.org/10.1038/s41598-023-50595-2>
- Fradi, K., Bouich, A., Khattak, Y. H., Baig, F., Slimi, B., Soucase, B. M., & Chtourou, R. (2024). Advancements in bandgap engineering: Bromide-doped cesium lead perovskite thin films. *Journal of Materials Science: Materials in Engineering*, 19(1), 14. <https://doi.org/10.1186/s40712-024-00156-w>
- Huang, D., Bo, J., Zheng, R., Luo, C., Sun, X., Li, Q., Shen, D., Zheng, Z., Chen, M., Yang, Y., Tang, A., Chen, S., & Chen, Y. (2021). Luminescence and Stability Enhancement of CsPbBr₃ Perovskite Quantum Dots through Surface Sacrificial Coating. *Advanced Optical Materials*, 9(16), 2100474. <https://doi.org/10.1002/adom.202100474>
- Kambhampati, P. (2021). Nanoparticles, Nanocrystals, and Quantum Dots: What are the Implications of Size in Colloidal Nanoscale Materials? *The Journal of Physical Chemistry Letters*, 12(20), 4769–4779. <https://doi.org/10.1021/acs.jpclett.1c00754>
- Klimov, V. I., Mikhailovsky, A. A., Xu, S., Malko, A., Hollingsworth, J. A., Leatherdale, C. A., Eisler, H.-J., & Bawendi, M. G. (2000). Optical Gain and Stimulated Emission in Nanocrystal Quantum Dots. *Science*, 290(5490), 314–317. <https://doi.org/10.1126/science.290.5490.314>
- Liu, F., Zhang, Y., Ding, C., Kobayashi, S., Nakazawa, N., Toyoda, T., Ohta, T., Minemoto, T., Yoshino, K., Dai, S., & Shen, Q. (n.d.). *Highly Luminescent Phase-Stable CsPbI₃ Perovskite Quantum Dots Achieving Near 100% Absolute Photoluminescence Quantum Yield*.

Online ISSN

3007-3197

Print ISSN

3007-3189

<http://amresearchreview.com/index.php/Journal/about>

- Liu, Y., Tang, S., Gao, Z., Shao, X., Zhu, X., Ràfols Ribé, J., Wågberg, T., Edman, L., & Wang, J. (2023). The influence of the capping ligands on the optoelectronic performance, morphology, and ion liberation of CsPbBr₃ perovskite quantum dots. *Nano Research*, 16(7), 10626–10633. <https://doi.org/10.1007/s12274-023-5589-y>
- López, C. A., Abia, C., Alvarez-Galván, M. C., Hong, B.-K., Martínez-Huerta, M. V., Serrano-Sánchez, F., Carrascoso, F., Castellanos-Gómez, A., Fernández-Díaz, M. T., & Alonso, J. A. (2020). Crystal Structure Features of CsPbBr₃ Perovskite Prepared by Mechanochemical Synthesis. *ACS Omega*, 5(11), 5931–5938. <https://doi.org/10.1021/acsomega.9b04248>
- Mannino, G., Deretzis, I., Smecca, E., La Magna, A., Alberti, A., Ceratti, D., & Cahen, D. (2020). Temperature-Dependent Optical Band Gap in CsPbBr₃, MAPbBr₃, and FAPbBr₃ Single Crystals. *The Journal of Physical Chemistry Letters*, 11(7), 2490–2496. <https://doi.org/10.1021/acs.jpcllett.0c00295>
- Mi, C., Gee, G. C., Lander, C. W., Shin, D., Atteberry, M. L., Akhmedov, N. G., Hidayatova, L., DiCenso, J. D., Yip, W. T., Chen, B., Shao, Y., & Dong, Y. (2025). Towards non-blinking and photostable perovskite quantum dots. *Nature Communications*, 16(1), 204. <https://doi.org/10.1038/s41467-024-55619-7>
- Mursyalaat, V., Variiani, V. I., Arsyad, W. O. S., & Firihu, M. Z. (2023). The development of program for calculating the band gap energy of semiconductor material based on UV-Vis spectrum using delphi 7.0. *Journal of Physics: Conference Series*, 2498(1), 012042. <https://doi.org/10.1088/1742-6596/2498/1/012042>
- Pan, H., Li, X., Zhang, X., Liu, J., Chen, X., Zhang, H., Huang, A., & Xiao, Z. (2020). Effect of Oleamine on Microwave-Assisted Synthesis of Cesium Lead Bromide Perovskite Nanocrystals. *Langmuir*, 36(45), 13663–13669. <https://doi.org/10.1021/acs.langmuir.0c02590>
- Pan, Q., Zhao, Q., Wei, P., & Li, G. (2025). Surface Ligands for Perovskite Quantum Dots. *ChemSusChem*, 18(4), e202401875. <https://doi.org/10.1002/cssc.202401875>

Online ISSN

3007-3197

Print ISSN

3007-3189

<http://amresearchreview.com/index.php/Journal/about>

- Peng, L., Tang, A., Yang, C., & Teng, F. (2016). Size-controlled synthesis of highly luminescent organometal halide perovskite quantum dots. *Journal of Alloys and Compounds*, 687, 506–513. <https://doi.org/10.1016/j.jallcom.2016.06.162>
- Pradhan, N. (2019). Tips and Twists in Making High Photoluminescence Quantum Yield Perovskite Nanocrystals. *ACS Energy Letters*, 4(7), 1634–1638. <https://doi.org/10.1021/acsenergylett.9b00946>
- Saleem, M. I., Yang, S., Sulaman, M., Hu, J., Chandrasekar, P. V., Shi, Y., Zhi, R., Batool, A., & Zou, B. (2020). All-solution-processed UV-IR broadband trilayer photodetectors with CsPbBr₃ colloidal nanocrystals as carriers-extracting layer. *Nanotechnology*, 31(16), 165502. <https://doi.org/10.1088/1361-6528/ab667b>
- Swarnkar, A., Chulliyil, R., Ravi, V. K., Irfanullah, M., Chowdhury, A., & Nag, A. (2015). Colloidal CsPbBr₃ Perovskite Nanocrystals: Luminescence beyond Traditional Quantum Dots. *Angewandte Chemie International Edition*, 54(51), 15424–15428. <https://doi.org/10.1002/anie.201508276>
- Yan, A., Guo, Y., Liu, C., Deng, Z., Guo, Y., & Zhao, X. (2018). Tuning the Optical Properties of CsPbBr₃ Nanocrystals by Anion Exchange Reactions with CsX Aqueous Solution. *Nanoscale Research Letters*, 13(1), 185. <https://doi.org/10.1186/s11671-018-2592-4>
- Yang, Y., Zheng, Y., Cao, W., Titov, A., Hyvonen, J., Manders, J. R., Xue, J., Holloway, P. H., & Qian, L. (2015). High-efficiency light-emitting devices based on quantum dots with tailored nanostructures. *Nature Photonics*, 9(4), 259–266. <https://doi.org/10.1038/nphoton.2015.36>
- Yu, Y., Fan, G., Fermi, A., Mazzaro, R., Morandi, V., Ceroni, P., Smilgies, D.-M., & Korgel, B. A. (2017). Size-Dependent Photoluminescence Efficiency of Silicon Nanocrystal Quantum Dots. *The Journal of Physical Chemistry C*, 121(41), 23240–23248. <https://doi.org/10.1021/acs.jpcc.7b08054>
- Zakaria, M. Q., Li, H., Shi, B., Wang, Y., Yu, J., Zhang, J., & Dai, Y. (2025). Ultrafast Laser Irradiation Enhances Crystallinity and Photoluminescence of Colloidal CsPbBr₃ Nanocrystals for High-Performance X-ray Detection. *ACS Applied Nano Materials*, 8(34), 16985–16993.

Online ISSN

3007-3197

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3007-3189

<http://amresearchreview.com/index.php/Journal/about>

<https://doi.org/10.1021/acsanm.5c03636>

Zhang, J., Crisp, R. W., Gao, J., Kroupa, D. M., Beard, M. C., & Luther, J. M. (2015). Synthetic Conditions for High-Accuracy Size Control of PbS Quantum Dots. *The Journal of Physical Chemistry Letters*, 6(10), 1830–1833. <https://doi.org/10.1021/acs.jpcelett.5b00689>

Zhang, Y., Aly, O. F., De Gorostiza, A., Shuga Aldeen, T., Segapeli, A. J., & Korgel, B. A. (2023). Cesium Methylammonium Lead Iodide ($\text{Cs}_x\text{MA}_{1-x}\text{PbI}_3$) Nanocrystals with Wide Range Cation Composition Tuning and Enhanced Thermal Stability of the Perovskite Phase. *Angewandte Chemie International Edition*, 62(31), e202306005. <https://doi.org/10.1002/anie.202306005>

Zhao, Y., Wei, S., Cao, X., Liu, Y., Chen, H., Lu, Z., Zhong, L., & Qiu, Y. (2025). Surface passivation of CsPbBr_3 nanoplates via multifunctional organic sulfate for enhanced photoluminescence, stability, and efficiency in blue-emitting perovskite-based devices. *Nano Energy*, 142, 111246. <https://doi.org/10.1016/j.nanoen.2025.111246>