Perovskite-on-polymer Light Diffusing Downconverter Powders

UNIVERSITY OF CENTRAL FLORIDA

Caicai Zhang[1, 2], Ziqian He[3], Hao Chen[1, 3], Guanjun Tan[3], Le Zhou[2], Shin-Tson Wu[3] and Yajie Dong[1, 2, 3, *]

[1]NanoScience Technology Center, University of Central Florida, Orlando, Florida, 32826, USA

[2]Department of Materials Science & Engineering, University of Central Florida, Orlando, Florida 32816, USA

[3]College of Optics and Photonics, University of Central Florida, Orlando, Florida 32816, USA

* Contact email: Yajie.Dong@ucf.edu

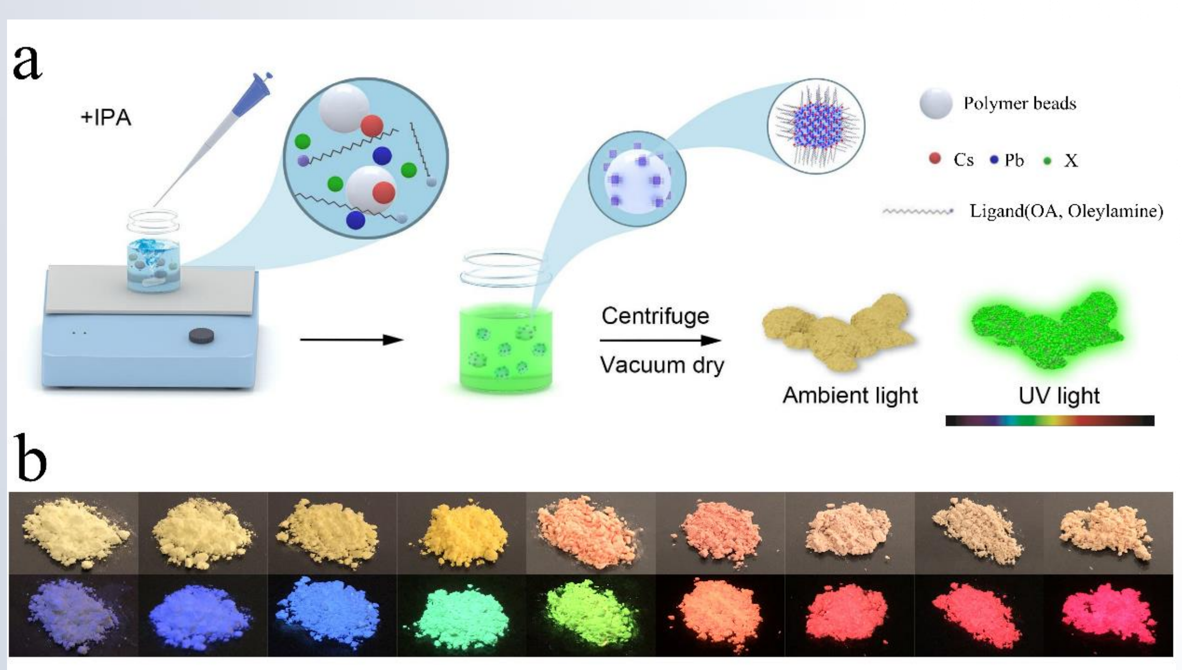
Introduction

In solid-state lighting (SSL) systems, homogeneous light sources with desired primary colors are generally preferred. Traditionally, the light homogeneity and the color conversion are achieved independently. Integrating downconverting and light-diffusing capabilities into one component can simplify the optical system design of luminaires and increase their optical efficiency. However, the high cost of traditional phosphors and QD downconverters has prohibited such a remote configuration in SSL since a large amount of expensive materials are needed which offset the saving gained through efficiency enhancement.

Metal halide perovskites (MHPs), particularly those with a chemical formula of $APbX_3$, where X is generally a halide (F^-, Cl^-, Br^-, I^-) have recently emerged as important low-cost solar photovoltaic or optoelectronic materials. MHP nanoparticles have demonstrated high luminescence efficiency, excellent color purity and outstanding color tunability to cover a full range of visible emission spectra simply by varying cation or halide compositions. Despite these progresses, instability under external stresses (remains one big challenge to be overcome.

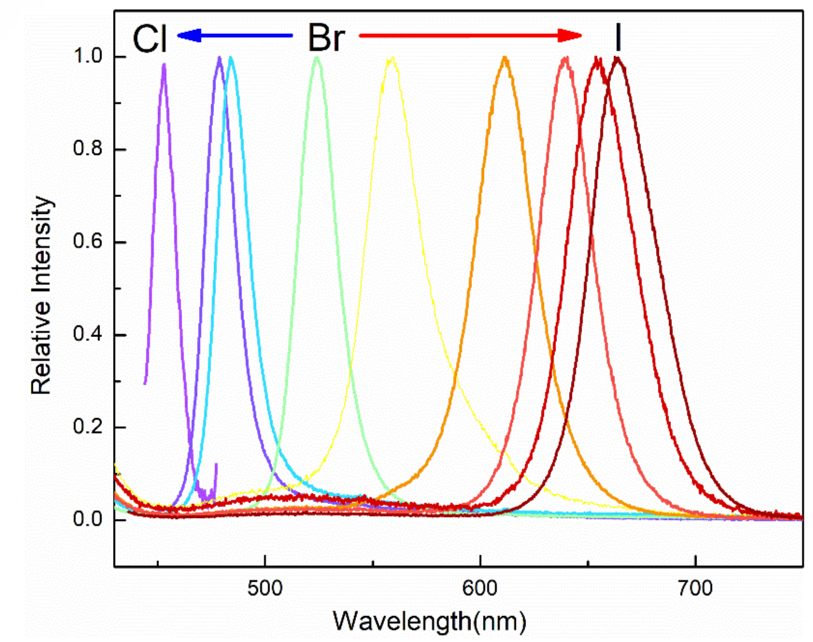
Herein, we report a one-step, general synthesis method that can convert commercial light-diffusing polymer powders into highly luminescent perovskite-based downconverters at an extremely low cost. This method creates well-dispersed perovskite nanoparticles anchored onto polymer powders and the whole process takes only several seconds at room temperature without any complex experimental. Significantly, the as-synthesized perovskite-on-polymer powders (PPPs) offer widely tunable, highly saturated colors, superior stability and light-diffusing capability.

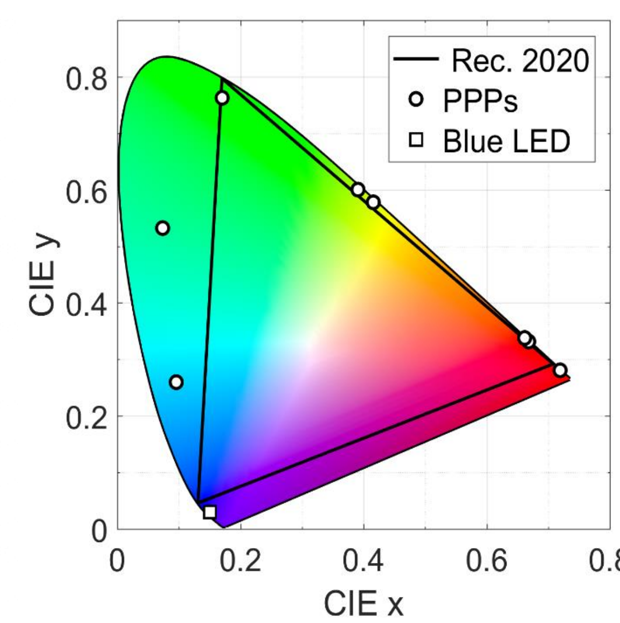
Method



- **Simple**, One step, room temperature perovskite nanocrystal nucleation on commercial light diffusing polymer powders induced by quick injection of anti-solvents (e.g. isopropyl alcohol (IPA)) .
- **Low cost** raw material precursor and equipment.
- **Widely tunable** emitting colors under UV excitation.

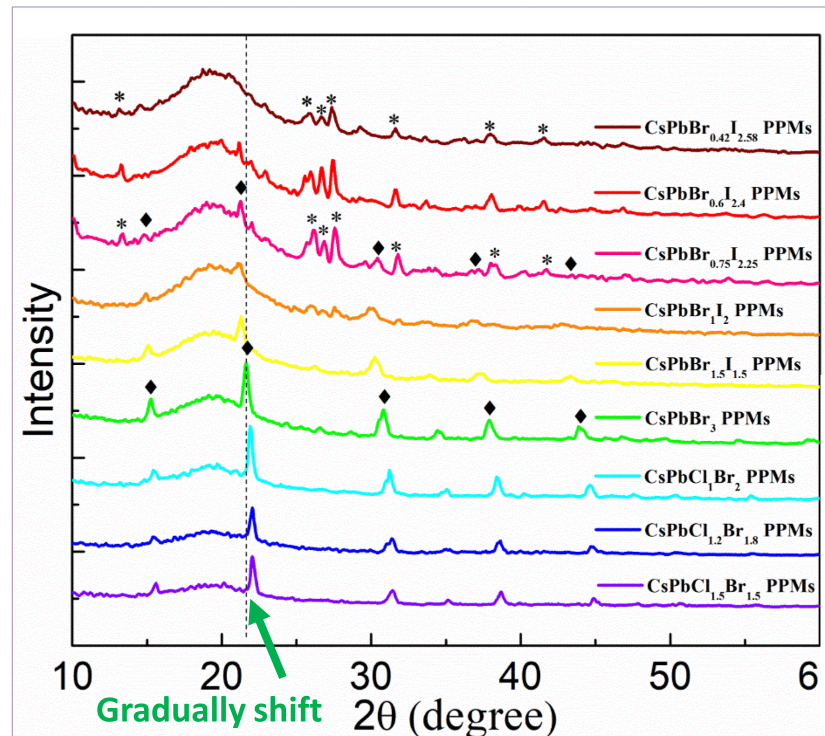
Optical Properties

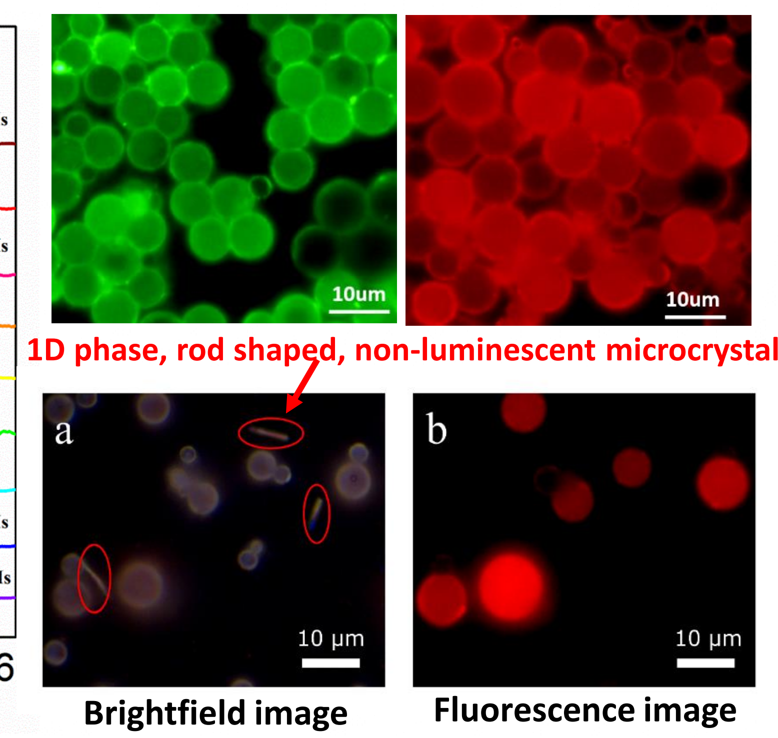




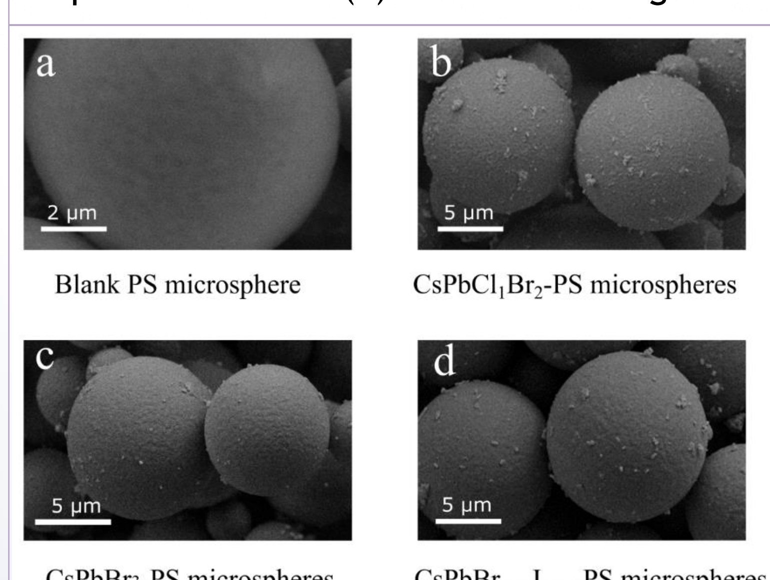
- Widely tunable emission peak positions of the obtained PPPs (453nm to 662nm).
- Ultrahigh color purity (FWHM from 12.5nm (blue) to 37nm (deep red)).
- Wide color gamut coverage range.

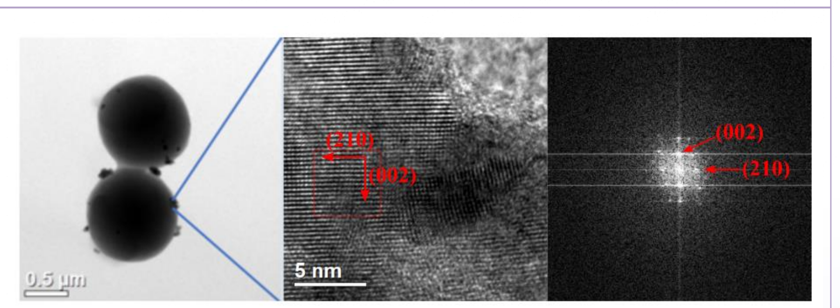
Structural Characterizations





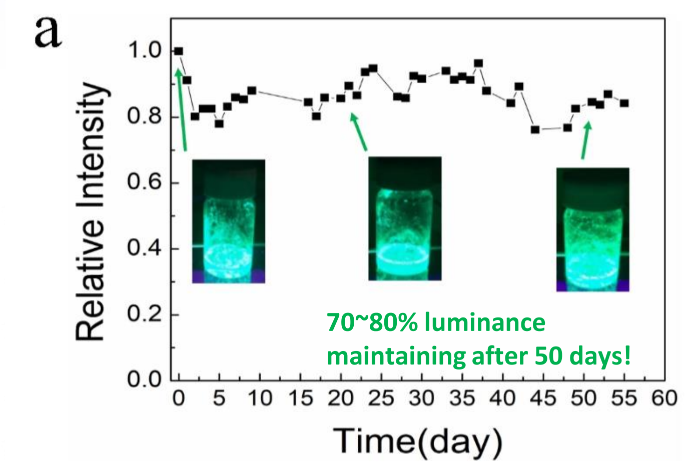
- XRD peak shift with composition change (Cl->Br->I) consistent w/ lattice constant trend.
- Coexistence of 3D luminescent perovskite structure (◆) and 1D non-luminescent "yellow" phase structure (*) for red emitting PPPs.

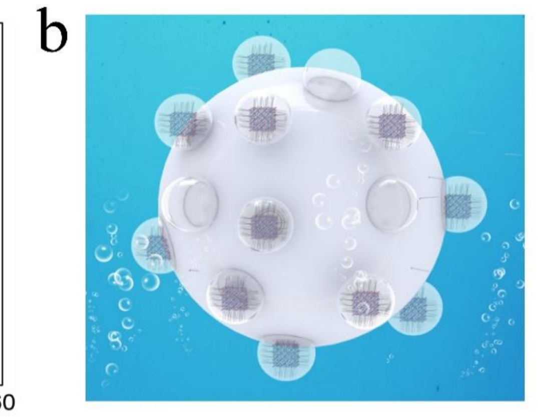


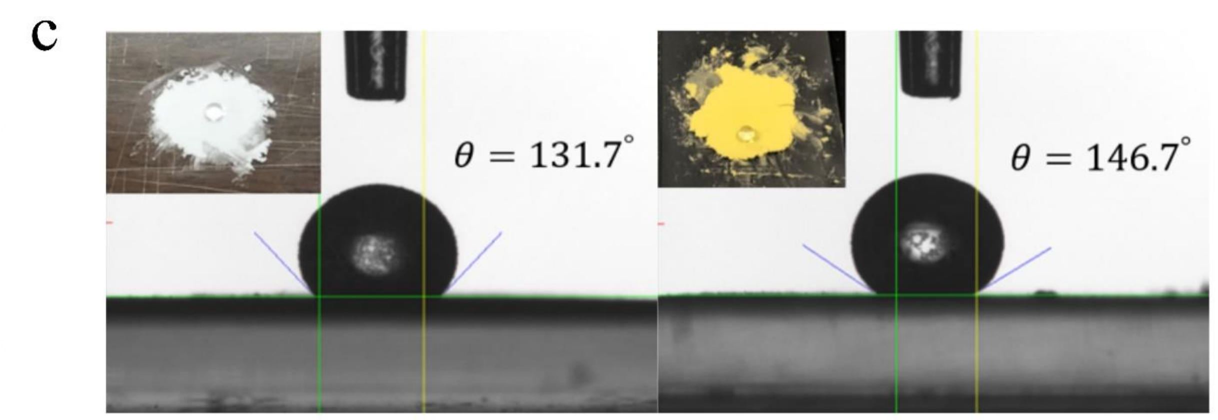


- **SEM** and **TEM** show the perovskite nanocrystals **anchored** at the polymer matrix surfaces.
- Calculated interplanar distances match 3D $CsPbBr_3$ perovskite structure.

Water Resistance Test

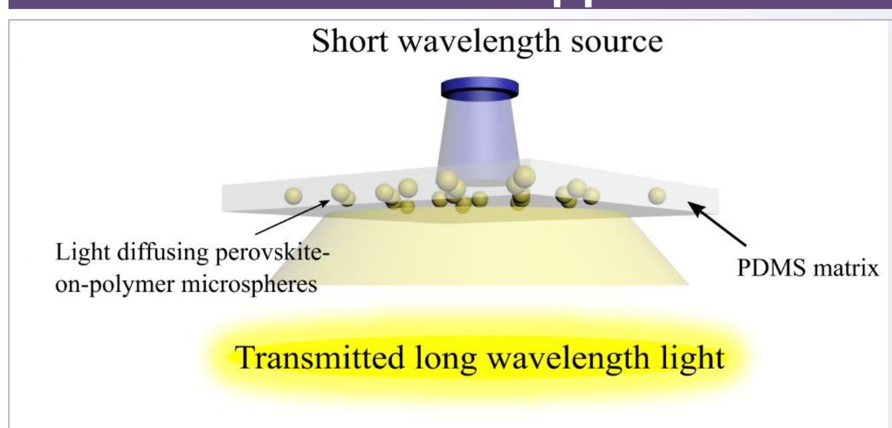


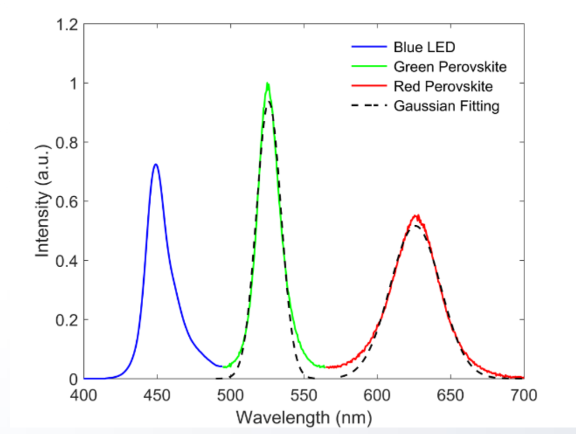


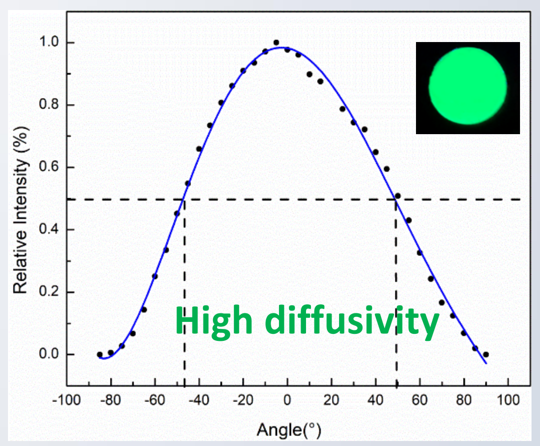


- Surprisingly good **water stability** of green PPPs.
- **Enhanced hydrophobicity** with anchoring perovskite nanocrystal.
- Air nanobubbles at the interface protect perovskites.

Applications







- Homogeneous light generation by combining PPPs-in-PDMS film with blue LEDs.
- High half-value-angle (HVA, 50°) proves good light diffusivity.

Conclusion

- These PPPs hold great promise to be adopted in emerging SSL systems as a low-cost, high-quality replacement for the traditional, expensive remote downconverters.

Acknowledgements

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Reference

- Zhang, C.; He, J.; Chen, H.; Tan, G.; Zhou, L.; Wu, S.; Dong, Y. J. Converting Light Diffusing Polymer Powders into Stable Perovskite- Based Tunable Downconverters. *SID Int. Symp. Dig. Tech. Pap.* **2018**, 49, 222–224.