Impact of Selected Ionic Liquids on the Properties of Metal Halide Perovskites

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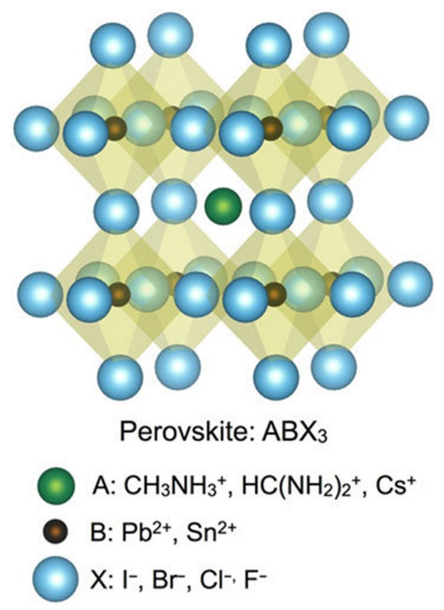
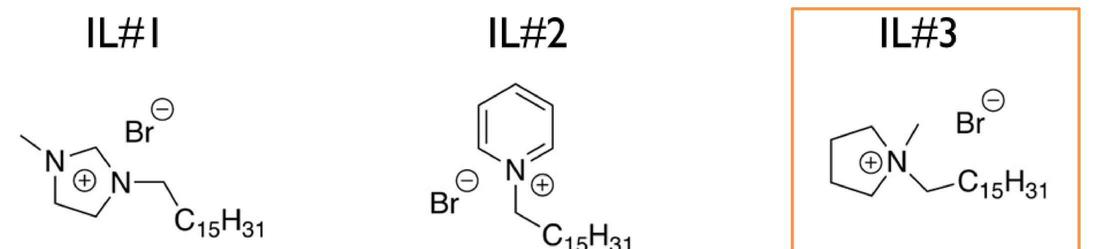
I. Introduction

Metal-halide perovskites are cubic crystalline materials that work as a semiconductor in both Light Emitting Diodes (LEDs) and solar cells. While they are easily fabricated, crystal size and number of defects are challenging to control. One approach to doing so is to use ionic liquids. Ionic liquids compounds made of ions in the liquid state due to a low melting temperature. They can be added to the perovskite precursor solution to slow down the crystallization process so that fewer defects are created. In this project, cetyl-ionic liquids are being investigated for their effects on perovskite structure and light emission. The three ionic liquids being investigated are [C16-mim]Br (referred to as "IL1"), [C16-py]Br ("IL2"), and [C16-C1pyrr]Br ("IL3").



IL= Ionic Liquid
MA= Methylammonium

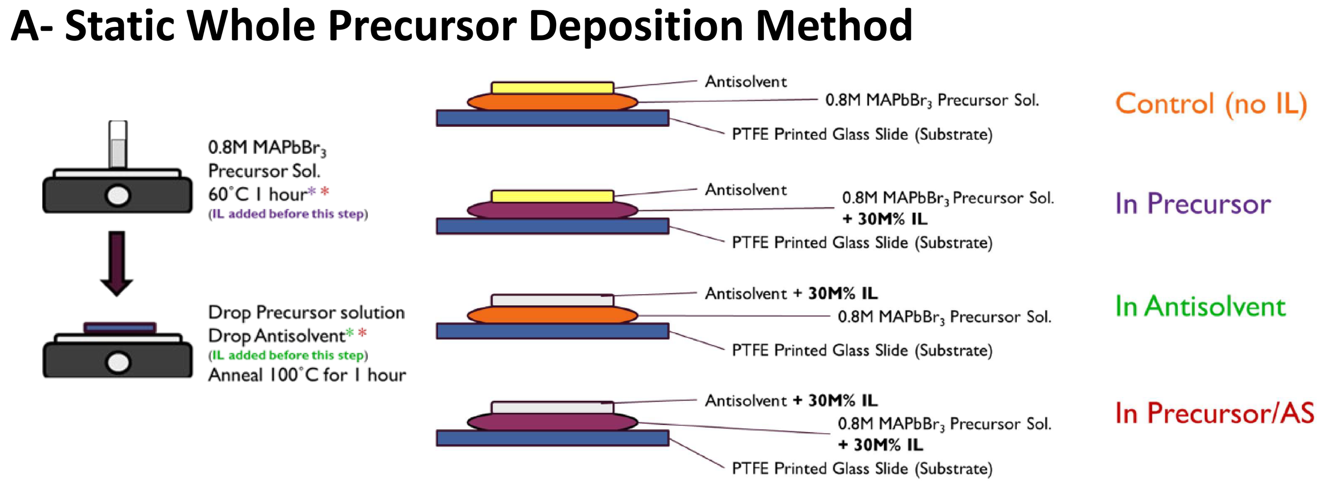


$[C_{16}$-mim]Br $[C_{16}$-py]Br $[C_{16}$-C_1pyrr]Br

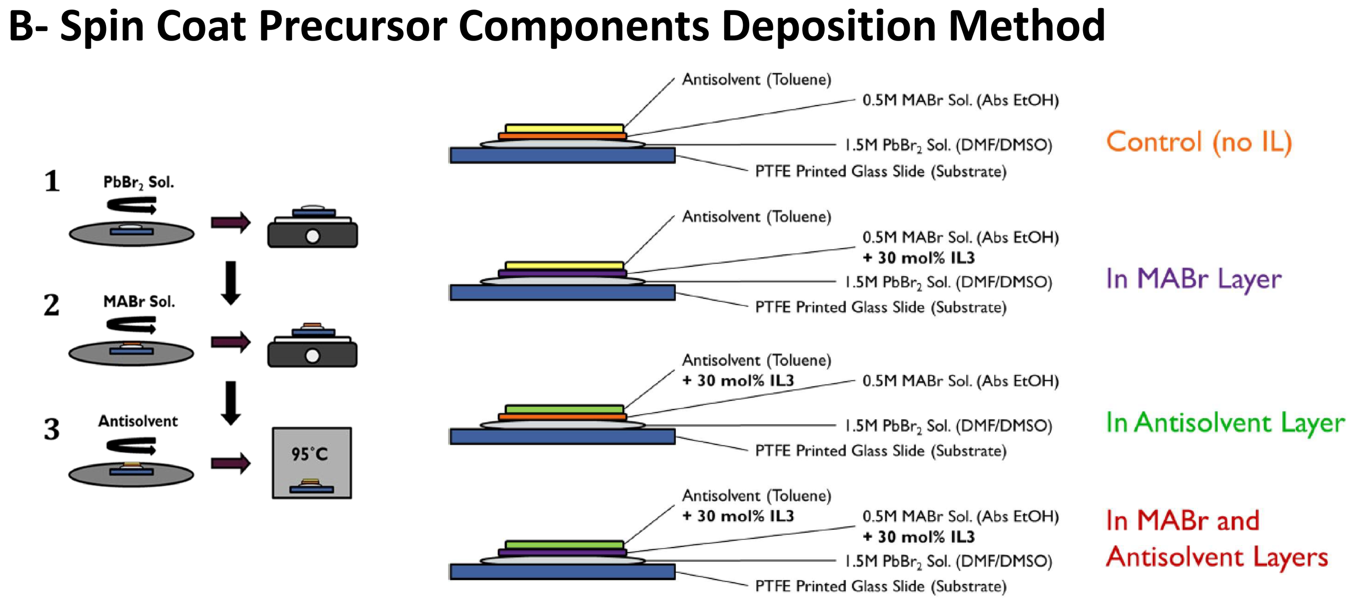
This presentation will focus on a variation of deposition methods of IL3 due to preliminary results suggesting that IL3 is more effective at increasing the photoluminescence of the perovskite films than IL1 and IL2. The goal of this project is to create new metal halide perovskites in the presence of selected ionic liquids and evaluate their structure and photophysical properties, with the long-term goal of creating new LEDs that are both stable and efficient.

II. Experimental

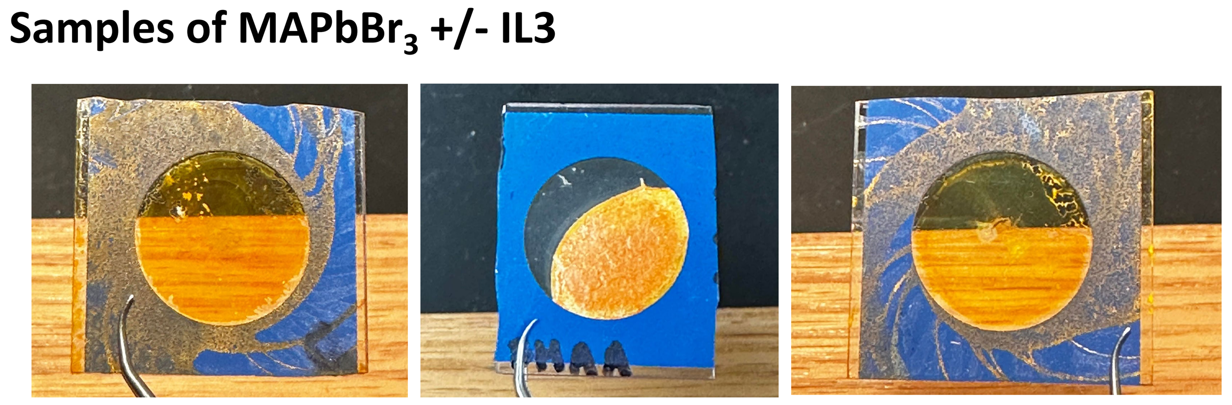
A- Static Whole Precursor Deposition Method



B- Spin Coat Precursor Components Deposition Method



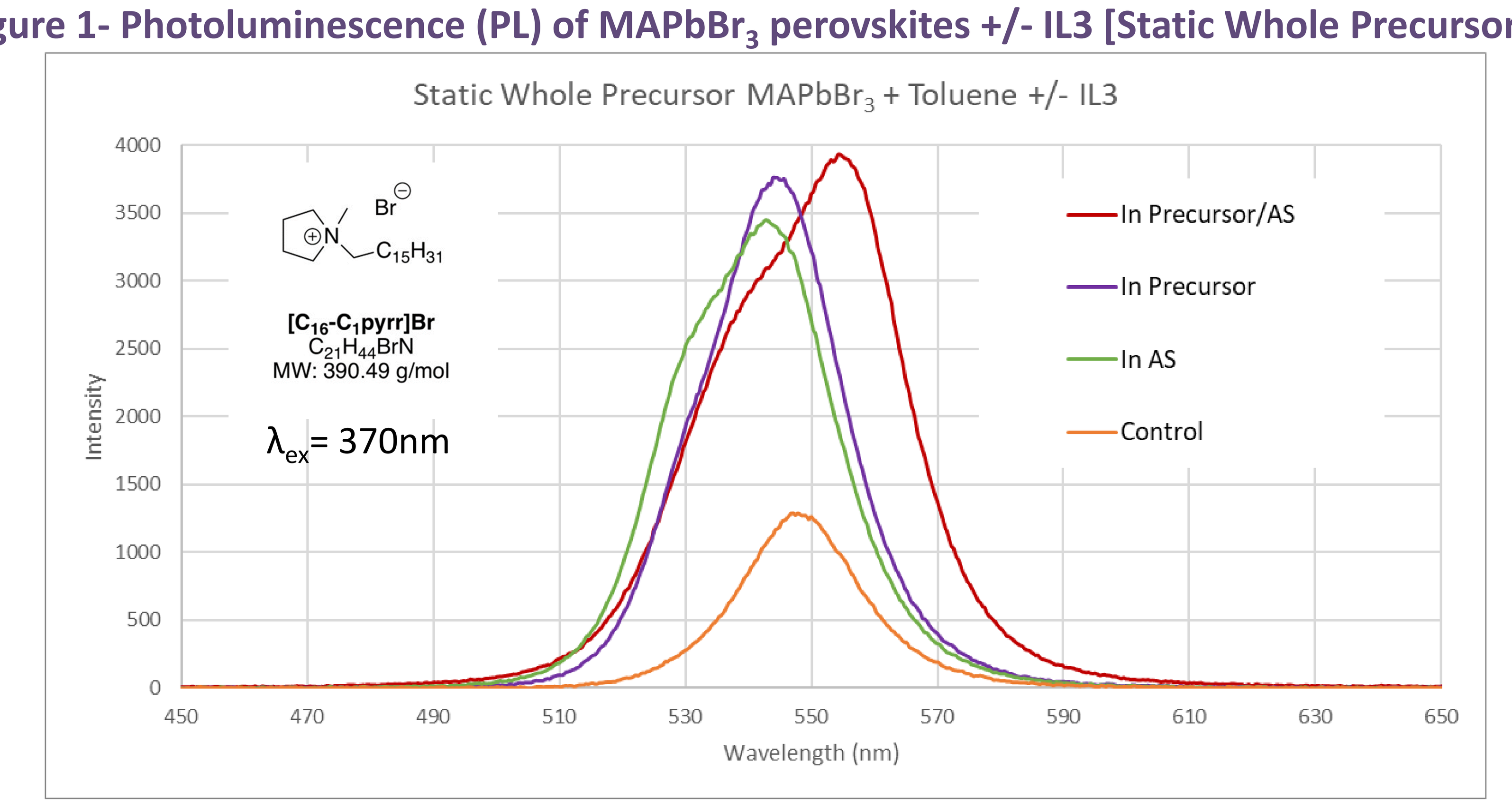
C- Samples of $MAPbBr_3$ +/- IL3



A- Spin Coat Control   B- Static In Precursor/AS   C- Spin Coat In MA/AS

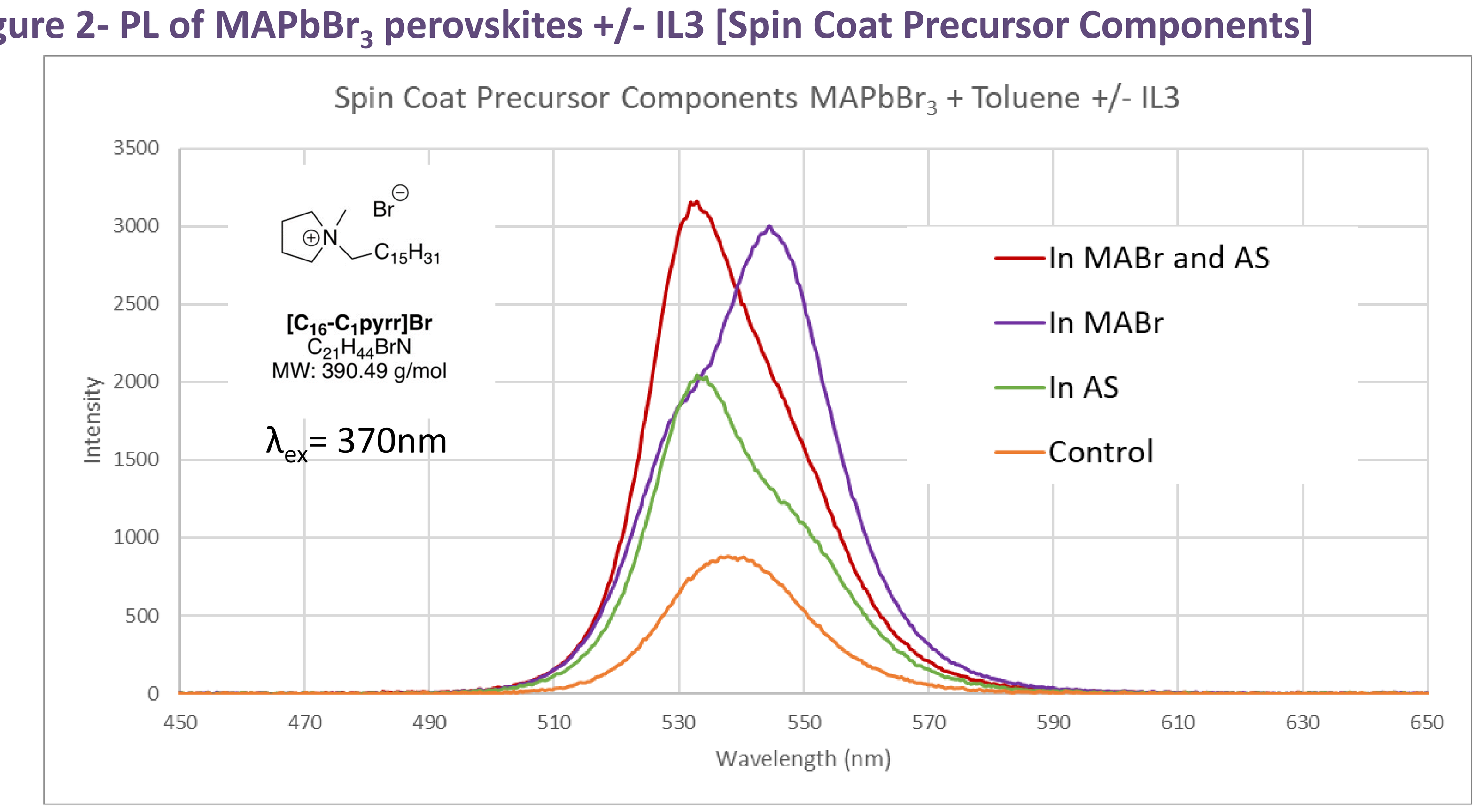
III. Results

Figure 1- Photoluminescence (PL) of $MAPbBr_3$ perovskites +/- IL3 [Static Whole Precursor]



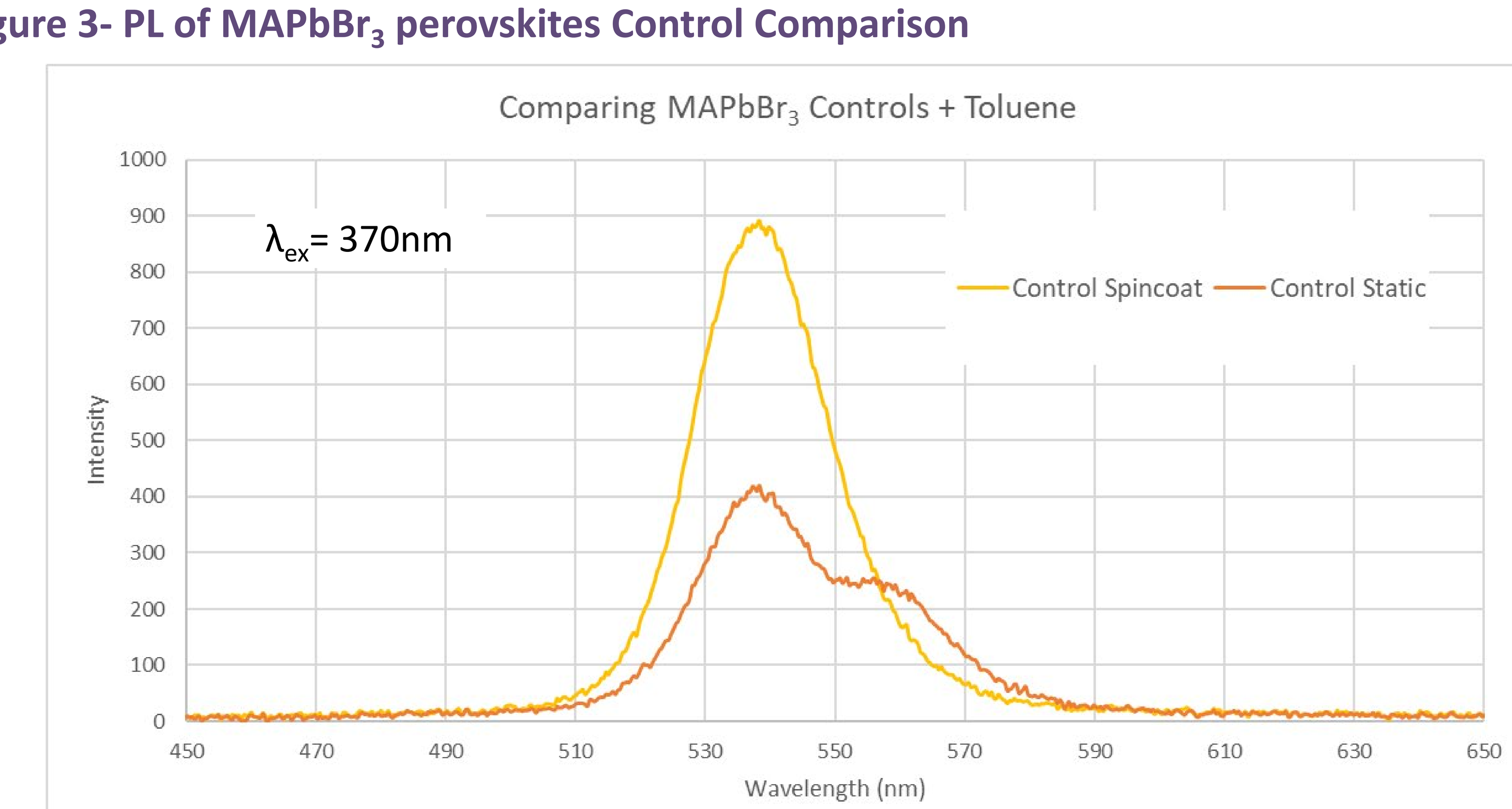
- $MAPbBr_3$ perovskites with IL3 in the precursor and AS layers had the most intense PL with the Static procedure

Figure 2- PL of $MAPbBr_3$ perovskites +/- IL3 [Spin Coat Precursor Components]



- $MAPbBr_3$ perovskites with IL3 in the MABr and AS layers had the most intense PL with the Spin Coating procedure

Figure 3- PL of $MAPbBr_3$ perovskites Control Comparison



- $MAPbBr_3$ perovskite films (no IL3) produced via the Spin Coat procedure had more intense PL then films produced by the Static procedure

Figure 4- Fluorescent Microscopy Images of $MAPbBr_3$ perovskites +/- IL3 (20x)

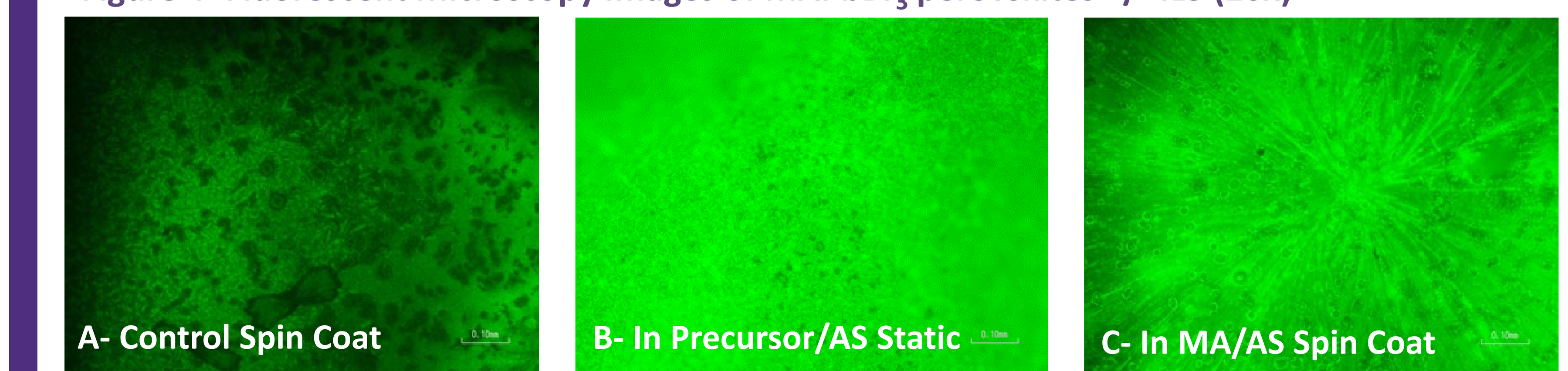
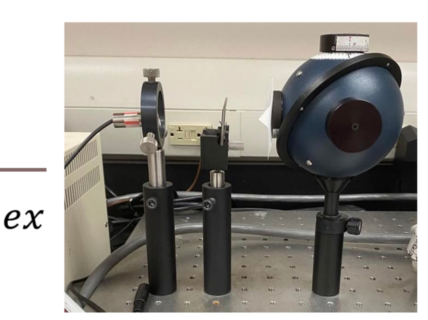


Figure 5- SEM Images of $MAPbBr_3$ Static vs Spin Coat (800x)

Figure 6- PL Quantum Efficiency (PLQE) Data of $MAPbBr_3$ +/- IL3 Static vs Spin Coat

Sample	PLQE (%)
Static In Precursor/AS	6.2
Static Control	Not detectable
Spin Coat In MABr/AS	33.0
Spin Coat Control	5.4

$$QE = \frac{A_{em}}{A_B - A_{ex}}$$



IV. Discussion

- Addition of IL3 in precursor or MABr and antisolvent layers increased the photoluminescence of the $MAPbBr_3$ perovskite films (Fig. 1 & 2)
- $MAPbBr_3$ perovskite films produced through the Spin Coat deposition had more intense photoluminescence (Fig. 3)
- Films with IL3 in MABr/AS layers were more uniform with the Spin Coat deposition compared to the static deposition (Fig. 5B/C) and showed an increase in quantum efficiency (Fig. 6)

V. Future Work

- Determine thickness of film with SEM cross section and profilometry
- Further determine relationship between ionic liquid structures and crystal growth of perovskite
- Test IL1 and IL2 with new deposition methods (spin coat procedure)
- Expand into tin chemistry with $MASnBr_3$ + IL perovskites

VI. References

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VII. Acknowledgments

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