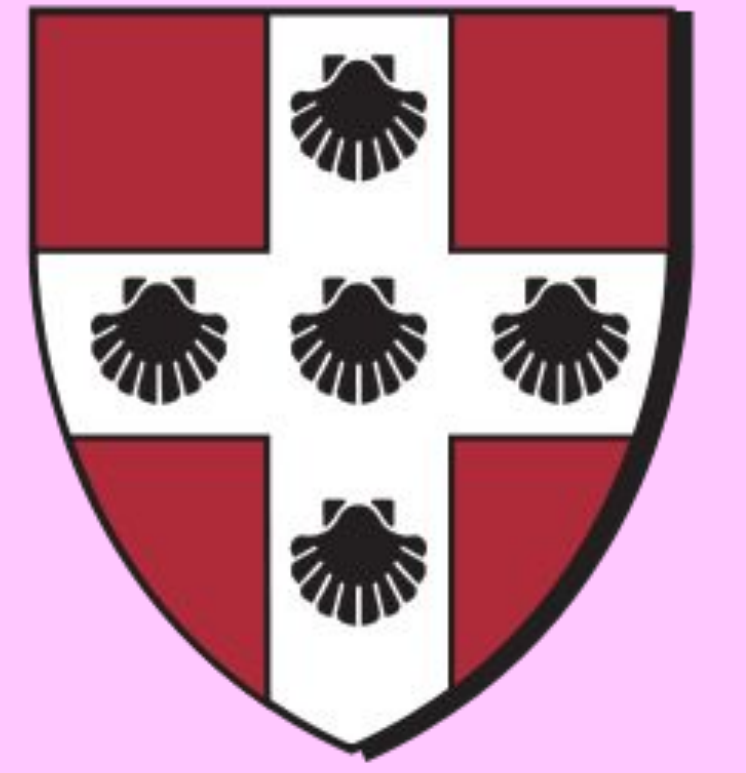# Comparing the Light Emission Dynamics of CsFA and MA Based Mixed Halide Perovskites

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Introduction

- Perovskites are compounds characterized by the chemical structure ABX_3. For solar cell applications:
  - A is a large cation (eg. Cs^+, MA^+, FA^+)
  - B is a smaller metallic cation (eg. Pb^{2+}, Sn^{2+})
  - X is an anion (eg. Cl^-, Br^-, I^-)

- They appear to be ideal for the production of solar cells, but several issues such as their poor stability limit their commercial applications.

- In particular, mixed halide perovskites (which incorporate several anions in their crystal structures) are a promising and versatile subset of perovskites thanks to their tunable optoelectronic properties, but are difficult to use because of a reversible process that occurs upon photoexcitation known as halide segregation (Figure 1).
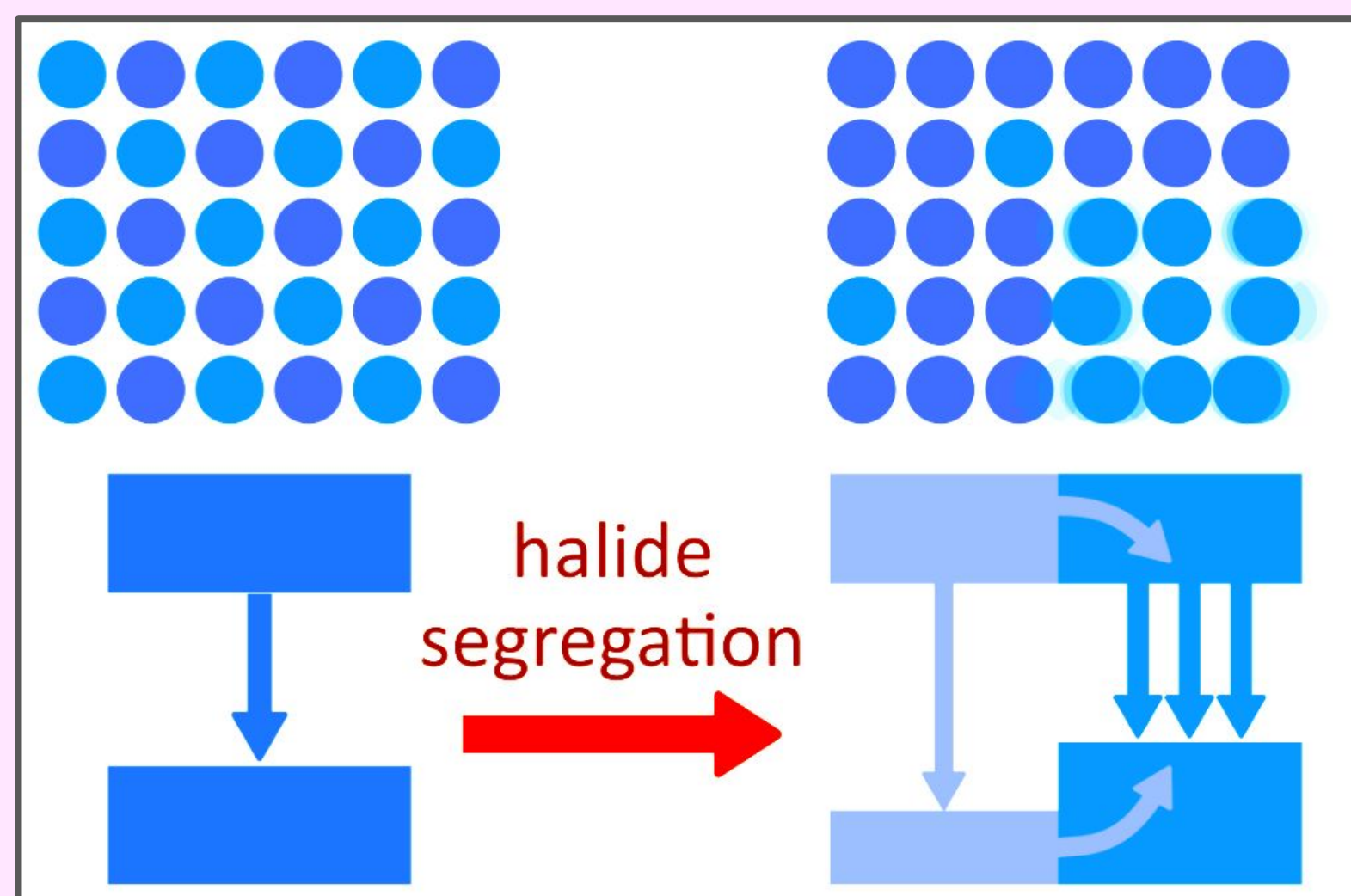

Figure 1. As the halides segregate, a region with a higher valence band edge is formed. When excited electrons move from the conduction band back down to the valence band, less energy is obtained as the band gap is narrower (which leads to a decrease in voltage). Figure adapted from Motti *et al.*, Proceedings HOPV21 conference.

- To better understand how the ratio of halides within a perovskite affects the process of halide segregation, we exposed several perovskite samples containing different ratios of iodide and bromide to a constant stream of photons. We then analyzed the light each sample emitted over time.

Methods

- Samples used:
  - $MAPb(Br_xI_{1-x})_3$
    x = 0, 0.33, 0.5, 0.67, 1
  - $Cs_{0.17}FA_{0.83}Pb(Br_xI_{1-x})_3$
    x = 0, 0.33, 0.5, 0.67, 1

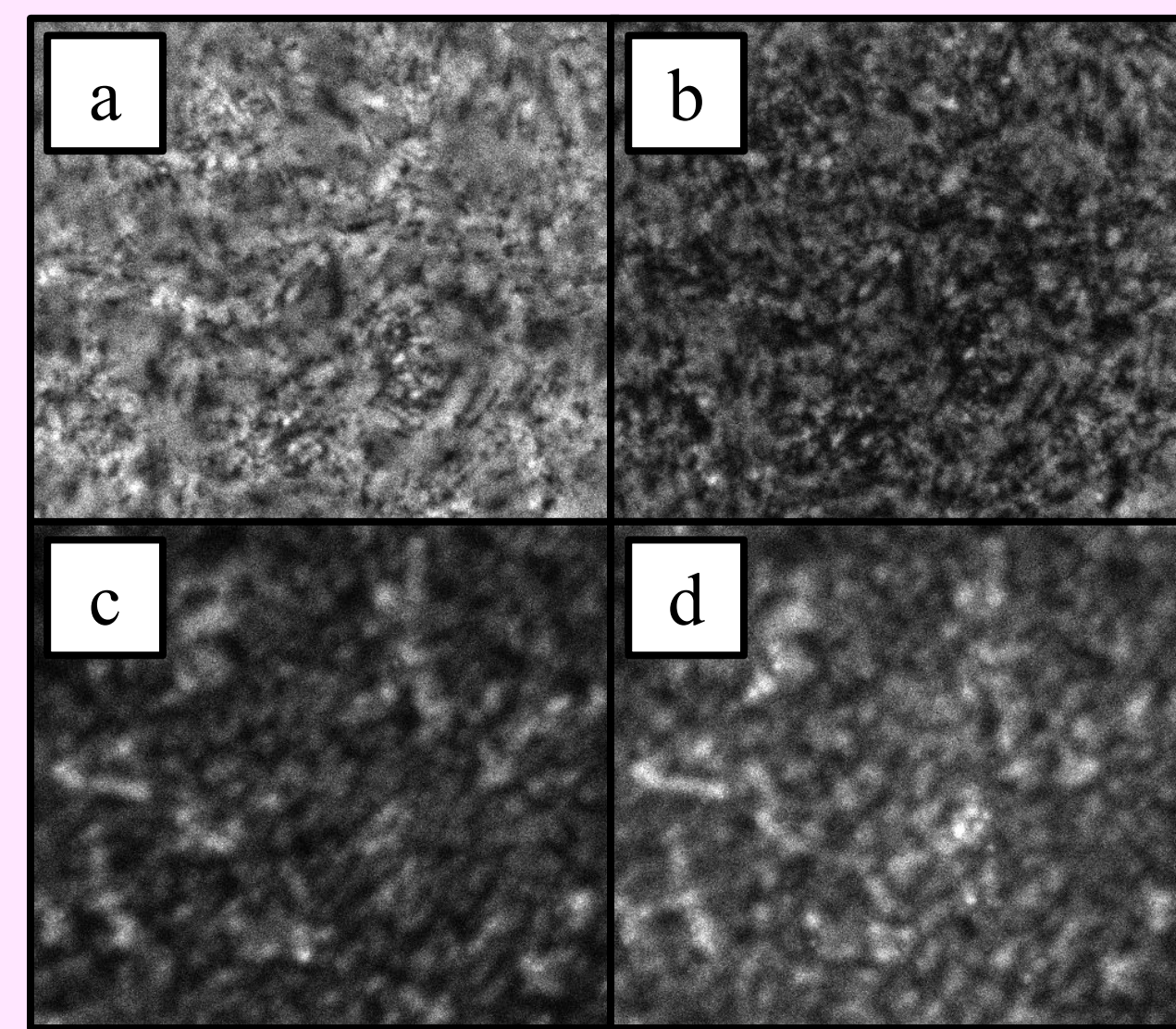- Samples were excited and light emission data was obtained using confocal microscopy (Figure 2).

Figure 2. Several confocal images of the $MAPb(Br_{0.67}I_{0.33})_3$ sample. **a** 565 - 590 nm, t = 0 s. **b** 565 - 590 nm, t = 523 s. **c** 690 - 715 nm, t = 0 s. **d** 690- 715 nm, t = 523 s. Images are approximately 58 μm across.
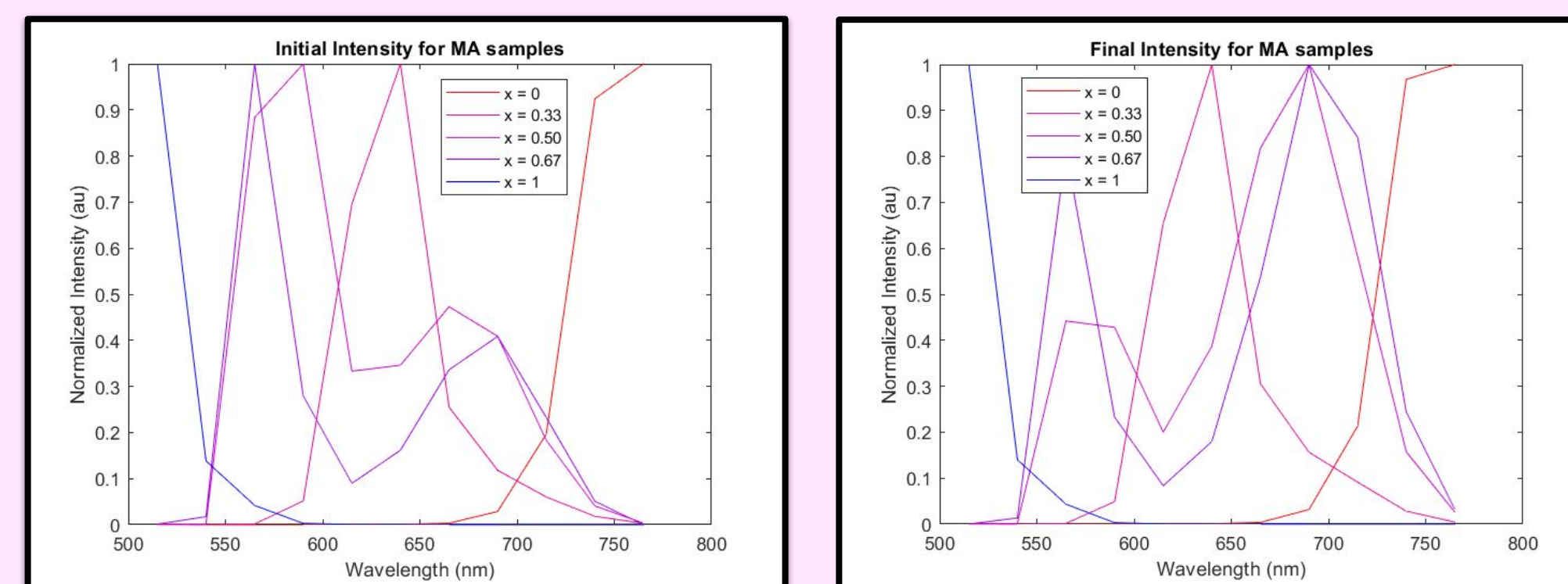
Results

Figure 3. Initial and Final Normalized Intensity vs Wavelength graphs for our MA based perovskite samples. The x = 0.5 and 0.67 samples appear to have two distinct emission peaks, while the x = 0, 0.33, and 1 samples have a singular emission peak.
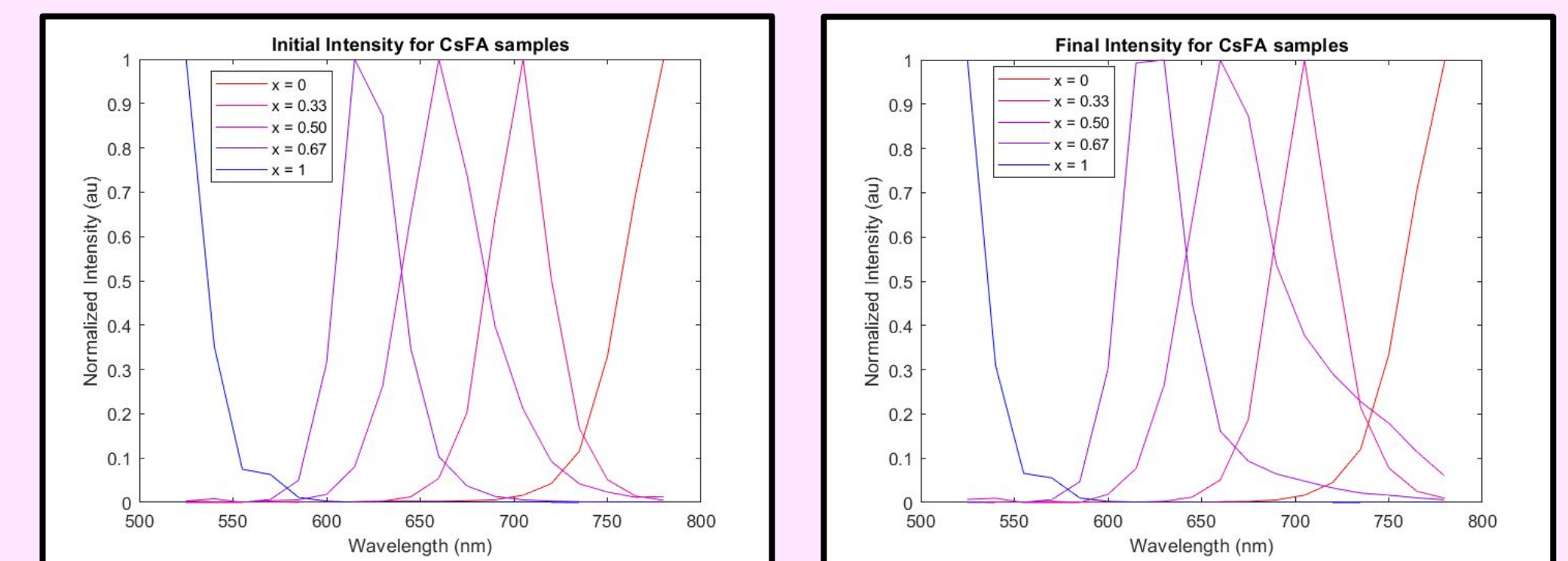
Results continued

Figure 4. Initial and Final Normalized Intensity vs Wavelength graphs for our $Cs_{0.17}FA_{0.83}$ based perovskite samples. All of the samples appear to have a singular emission peak.

The greater the percentage of bromide within a perovskite sample, the shorter the wavelength of its initial emission peak.

Given the same intensity of excitation light over the same time period, the $Cs_{0.17}FA_{0.83}$ based perovskite samples appear to show less dramatic light emission dynamics compared to the MA based perovskite samples.

Of the MA based mixed halide perovskite samples, the 33% bromide and 67% iodide sample appears to show the weakest light emission dynamics.

Future Work

- Collect more confocal data for the $Cs_{0.17}FA_{0.83}$ based perovskite samples using higher intensity excitation light (or scanning over a longer time period), to see if more halide segregation occurs or if the dynamics change beyond what we'd expect from a greater excitation intensity

- Take and analyze SEM (scanning electron microscopy) data for the $Cs_{0.17}FA_{0.83}$ based perovskite samples in order to examine grain size and surface structure for each sample