Reducing Environmental Contamination and Lead Leaching for Perovskite-based Photovoltaic Panels

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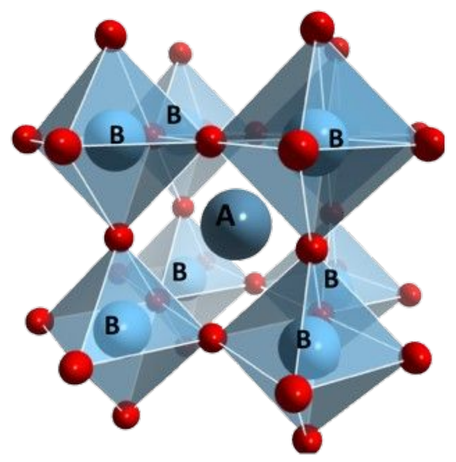
Introduction

Perovskites (ABX_3) are a new class of semiconductors with outstanding light absorption and low-cost processing compared to silicon. They can be produced from solution inks, making solar manufacturing cheaper and more flexible. Yet, these materials still face key barriers that limit large-scale production—instability under moisture and light, and the risk of lead contamination if panels crack.



A= Fa B=Pb X=I_3

After successfully producing uniform, high-performance $FaPbI_3$ films, the project now shifts focus to safety: preventing lead (Pb^{2+}) release if a solar panel fractures. Lead remains one of the main barriers to perovskite commercialization due to environmental and regulatory concerns. By demonstrating that ethylenediaminetetraacetic acid (EDTA) can effectively capture and mitigate lead exposure, this research aims to make lead-based perovskites a safer and more sustainable option for large-scale solar applications.

Materials & Methods

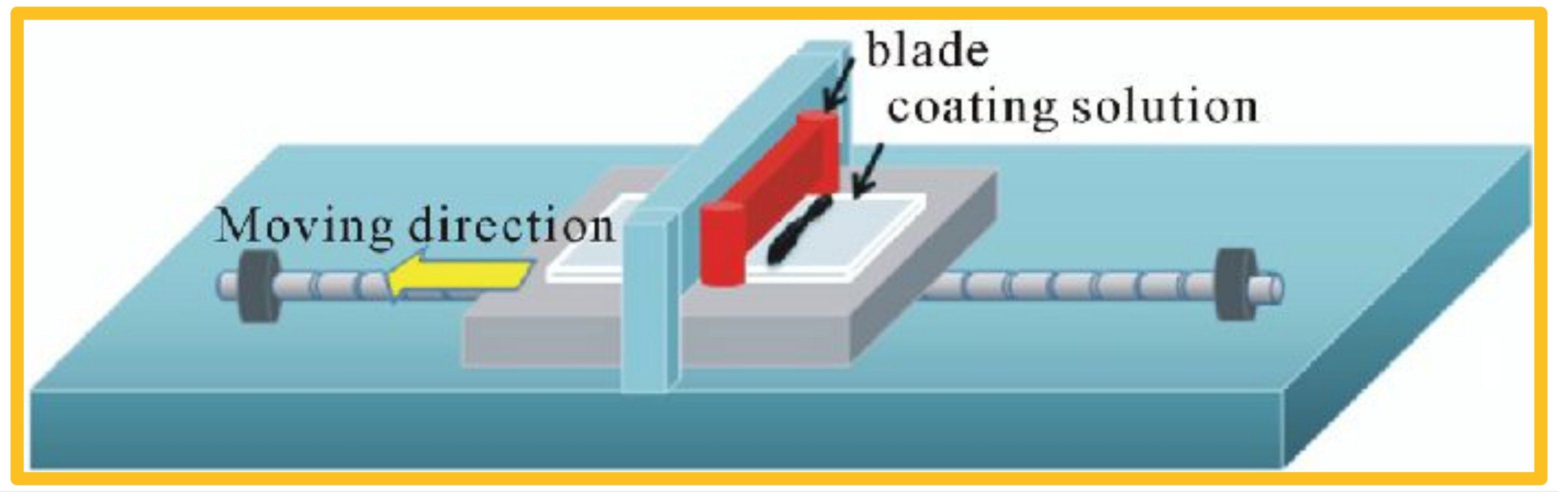


Fig. 1:
Blade coater used to spread the perovskite ink across the glass substrate.The chosen method for processing the films due to its scalability, uniform thickness control, and compatibility with large-area manufacturing.

The perovskite precursor ink was composed of formamidinium lead iodide ($FaPbI_3$) with starch added to improve film stability. Because EDTA was not soluble in the perovskite ink, several incorporation methods were tested. Mixing EDTA directly with the precursor ink, with dried powder, and under vacuum all proved unsuccessful. Ultimately, dissolving EDTA in deionized (DI) water allowed proper integration into the perovskite solution for uniform film formation.

Conclusions

EDTA incorporation into $FaPbI_3$ films was achieved through modified processing; however, the method did not produce the expected reduction in lead release. ICP-MS analysis showed that EDTA-containing samples exhibited the highest Pb concentrations under the conditions tested. As EDTA integration required higher molarity, the results do not isolate its effect, but instead highlight limitations in the current incorporation approach. These findings indicate that effective lead mitigation depends not only on the choice of additive, but critically on how it is integrated into the film.

Future Work

- Explore alternative methods to incorporate EDTA into perovskite films;
- Perform additional ICP-MS measurements to compare different incorporation strategies
- Compare aging behavior of EDTA-containing films with MAPI-based samples;
- Optimize formulations for effective lead immobilization in scalable systems

Results

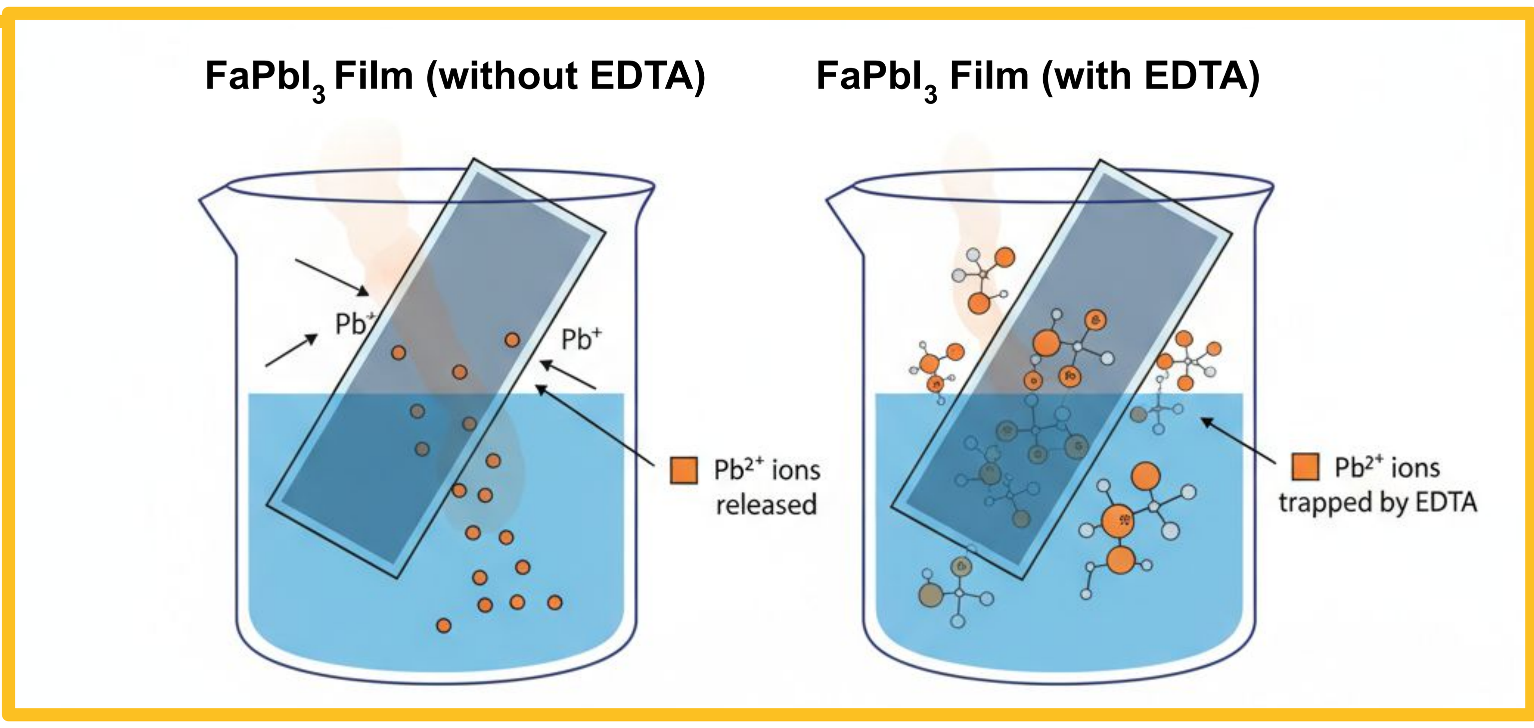
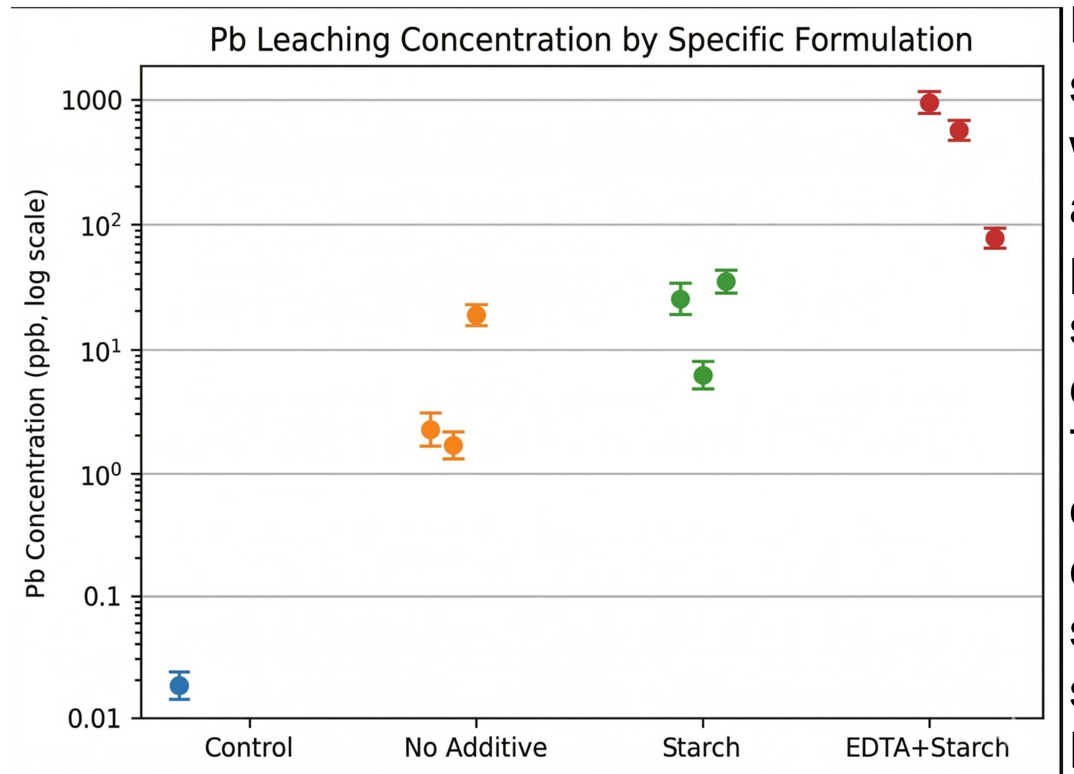


Fig. 2 Perovskite films (EDTA, starch + EDTA, and control) were submerged in 500 mL of DI water to allow Pb release into solution. After exposure, 1 mL of the collected solution was withdrawn and diluted with 9 mL of DI water prior to ICP-MS analysis. This dilution step ensured that Pb concentrations fell within the measurable range of the instrument. ICP-MS testing was used to quantify the lead concentration in solution. The effect illustrated in the figure represent a hypothesized mechanism of Pb capture and retention by EDTA within the perovskite films.

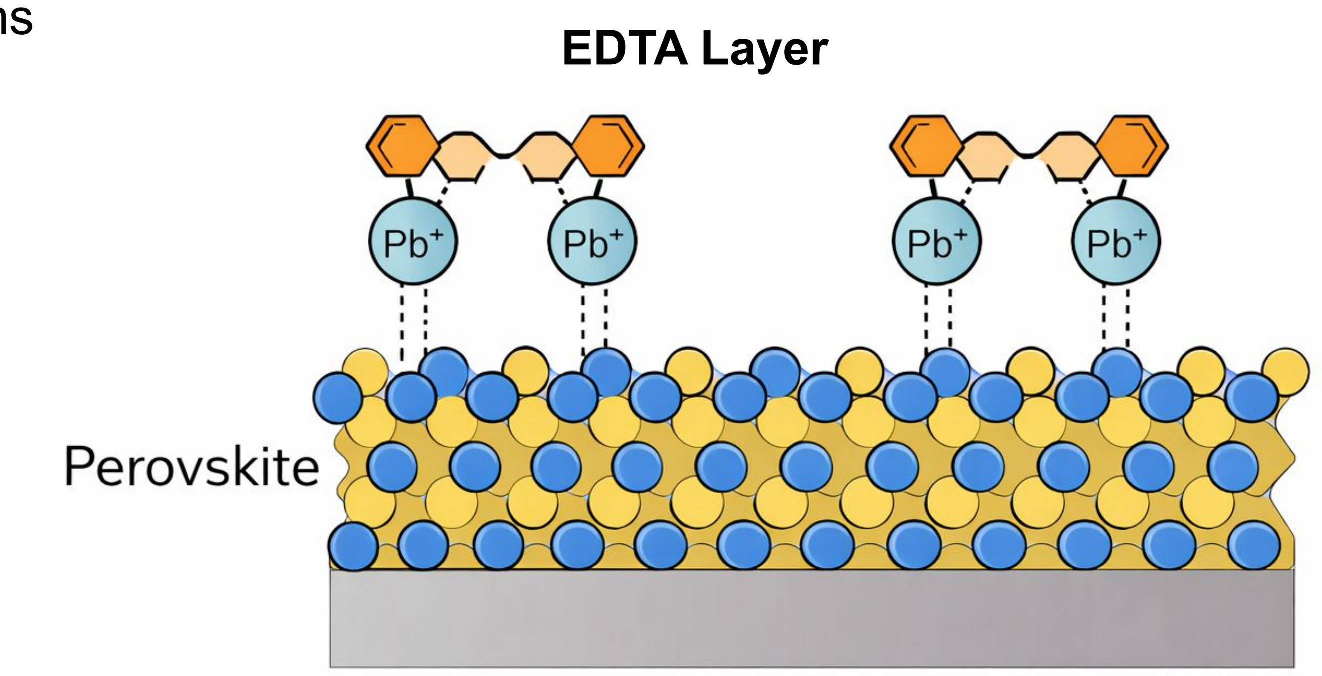


Challenges:

Identifying the right conditions for a more diluted perovskite ink to form a stable photoactive film and successfully integrate EDTA without affecting film quality significantly.

Each measurement represents a separate sample after exposure to DI water. A total of 10 samples were analyzed: DI water (control), three pure $FaPbI_3$ films, three starch-modified films, and three films containing both starch and EDTA. The EDTA-containing samples exhibited the highest Pb concentrations (>700 ppb), while starch and pure $FaPbI_3$ samples showed significantly lower Pb levels. Because the EDTA samples were prepared at higher molarity, these results reflect combined effects of formulation and precursor concentration rather than the isolated role of EDTA. Overall, the data indicate that lead release is strongly influenced by formulation conditions.

Fig. 3



References

1. *Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Blade-coating-operation_fig1_276491510 [accessed 1 Nov 2025]*

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