A Clearer Future: Investigating Semitransparent 2D Perovskite Thin Films for Solar Window Applications

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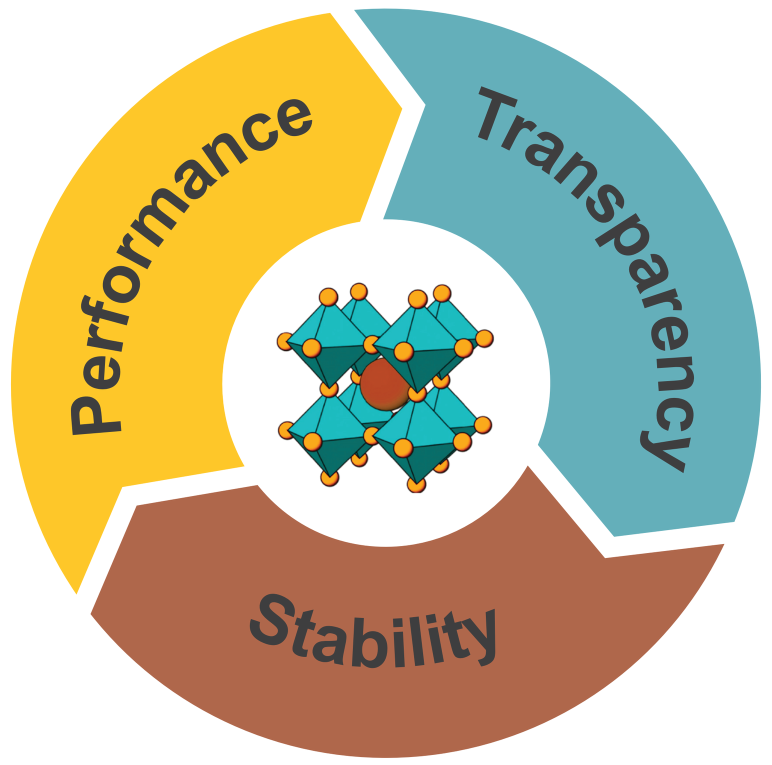
Introduction

Perovskites (PVK) are a rising class of semiconductor materials that have garnered the interest of the scientific community. With their ease of fabrication, low-cost starting materials, and innate tunability, PVK emerge as promising contenders for the development solar windows. The objective of this research is to engineer a PVK material with the right balance of transparency, stability, and performance needed for an effective absorber material in a semitransparent solar device. 2D PVK are investigated as a more stable alternative to 3D PVK. Povidone additive (PVP) is also studied for its effects on stability.



Materials & Methods

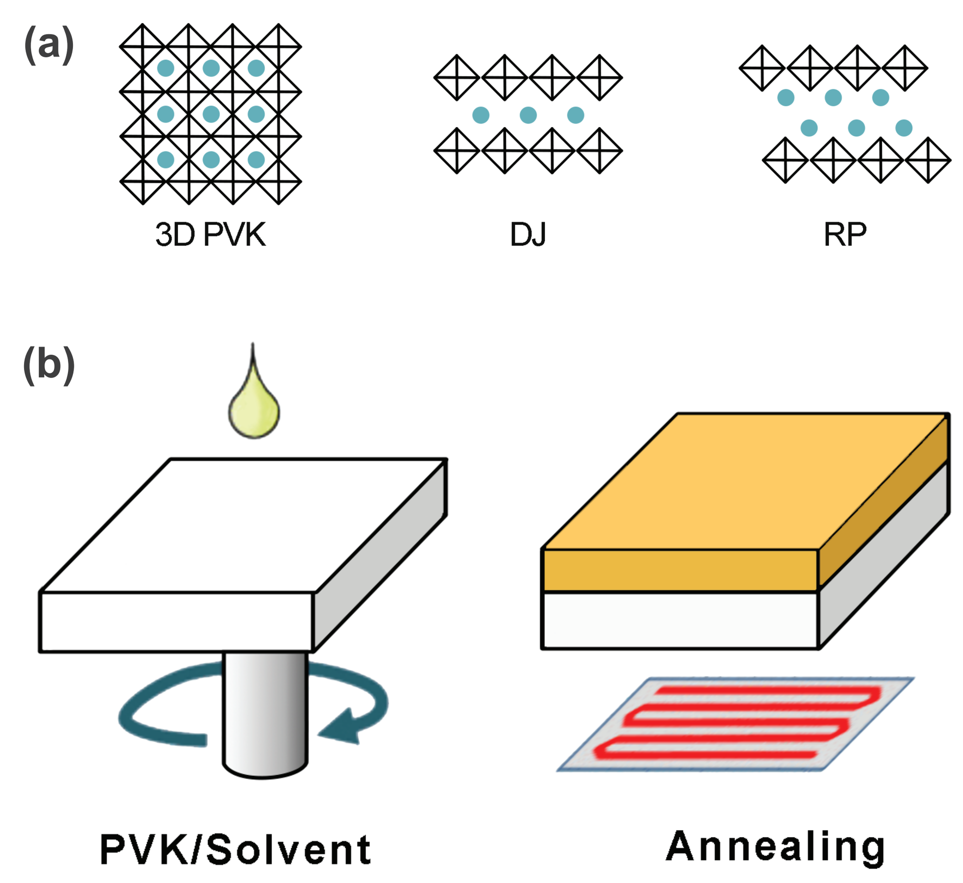
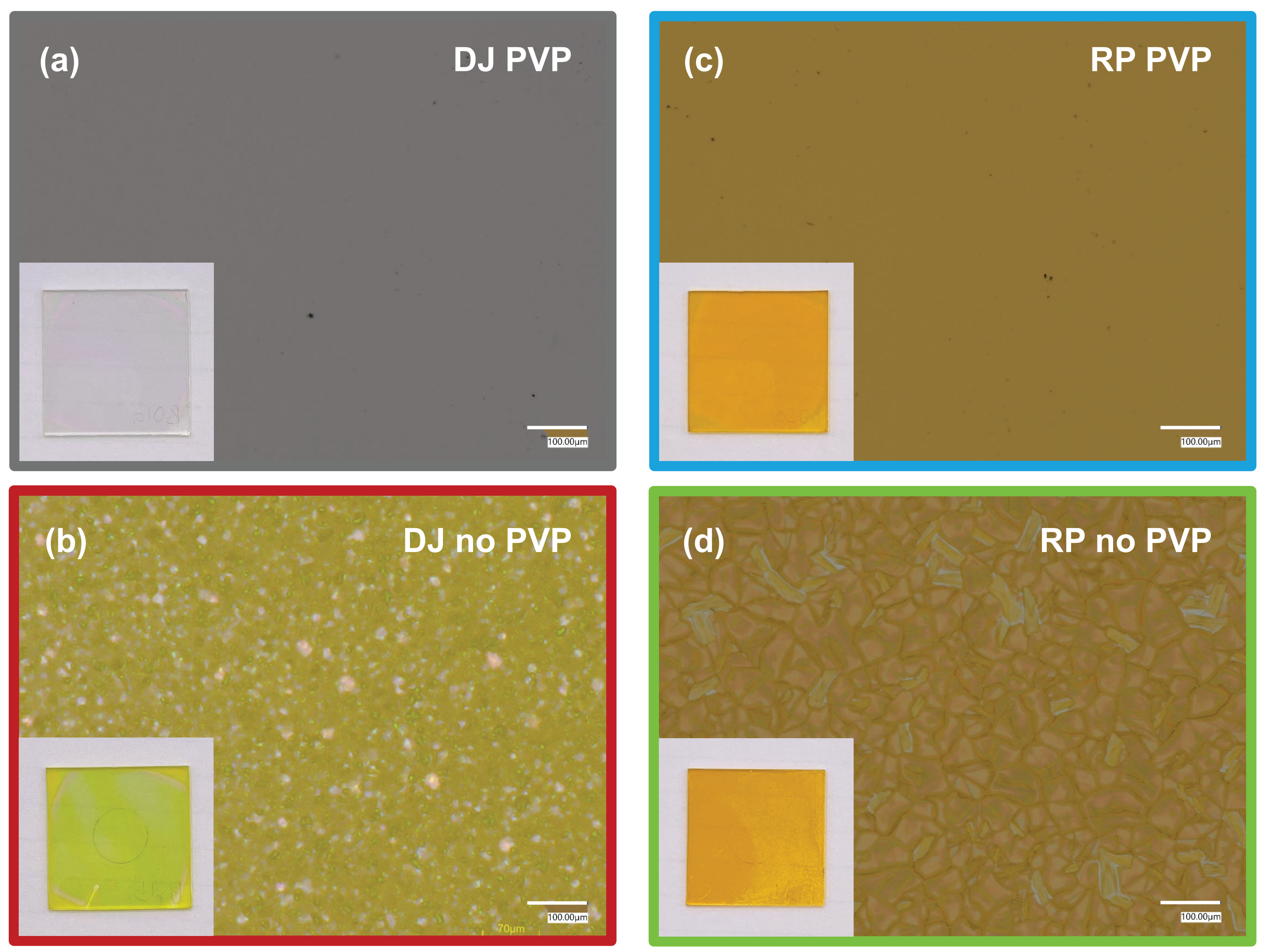
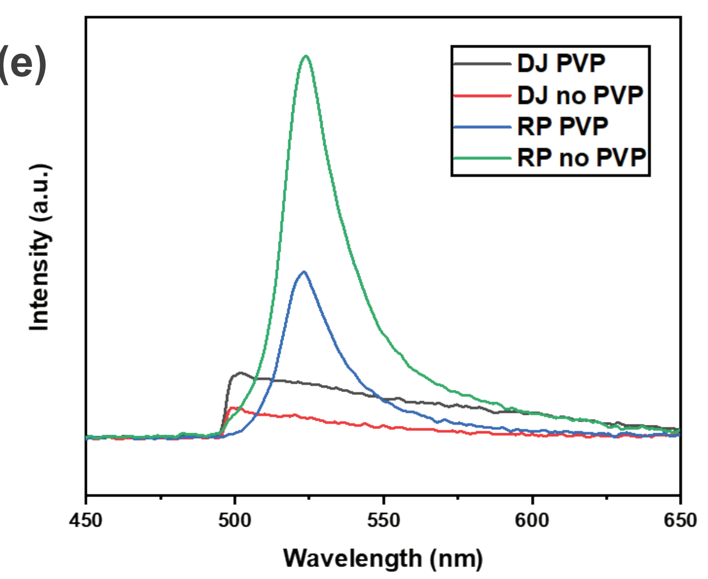


Fig. 1:
(a) Schematic illustrating the difference between 3D PVK and the RP and DJ phases of 2D PVK. The diamonds represent the lead iodide octahedra, and the teal dots represent the cation. The DJ and RP PVK used are propane diammonium lead iodide and butylammonium lead iodide, respectively.
(b) Schematic of the spin-coating process. The PVK ink is deposited on a glass substrate and spun at 4000 rpm for 30s, followed by annealing on a hot plate at 100°C for 10min.

Results





(f)

PVK	Eg (eV)	AVT (%)
DJ PVP	2.84	85
DJ no PVP	2.54	67
RP PVP	2.34	62
RP no PVP	2.34	55

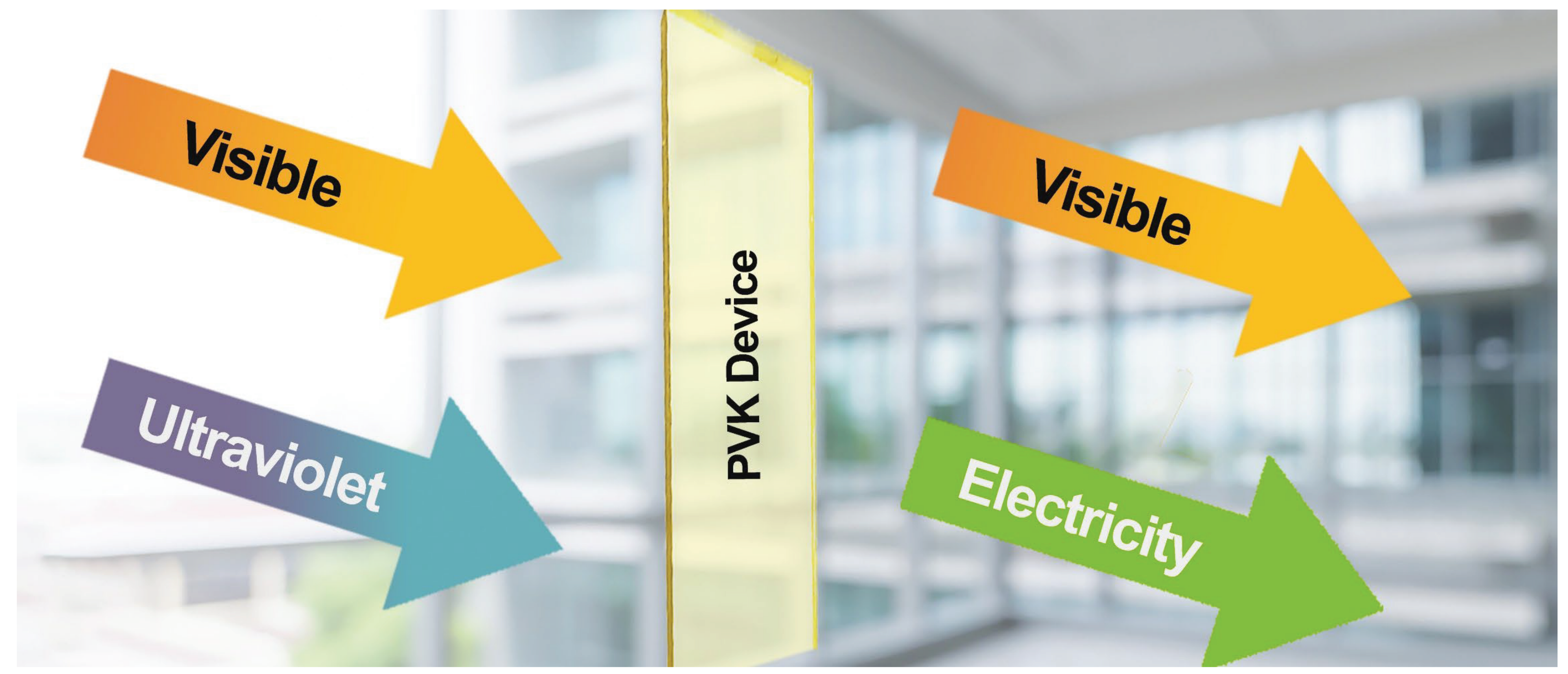
Fig. 2:
(a-b) Microscope images of uniform DJ PVK films with and without PVP added, respectively. Inset demonstrates color and morphology changes caused by adding PVP.
(c-d) Microscope images of RP PVK films with and without PVP added, respectively. Here, there is no significant color change with the addition of PVP, but the morphology is visibly altered. The film without PVP (d) shows large surface features not present in the sample with PVP added (c).
(e) Photoluminescence (PL) spectra of the 2D PVK films. The DJ samples did not produce any significant peaks, and the RP sample with no PVP added had the highest PL signal.
(f) Table of bandgap energies (Eg) and average visible transmittance (AVT) of the 2D PVK films. Bandgaps calculated using a Tauc plot. AVT was determined by averaging the transmittance within the visible light spectrum (380-780 nm).

Conclusions

2D PVK can create semiconducting films with high transparency—with the DJ PVP films achieving up to 85% AVT. Despite their high transparency, these films did not perform well electrically. The RP PVK without PVP prove very promising, as they demonstrated the best electrical performance while still maintaining good transparency.

Future Work

- Further analyze PL data of light- and heat-aged samples.
- Validate crystal phases present using X-Ray Diffraction (XRD).
- Experiment with blade coating on larger substrates as an alternative processing technique to improve the scalability of the perovskite thin films.
- Begin fabricating semitransparent devices to enable measurement of percent conversion efficiency (PCE), voltage, and fill factor.



References

1. *ACS Energy Lett.* 2020, 5, 1519–1531
2. *J. Am. Chem. Soc.* 2014, 136, 46, 16411–16419
3. *J. Mater. Chem. A.* 2018, 6, 14307
4. *Nature Mater.* 2014, 13, 897–903

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