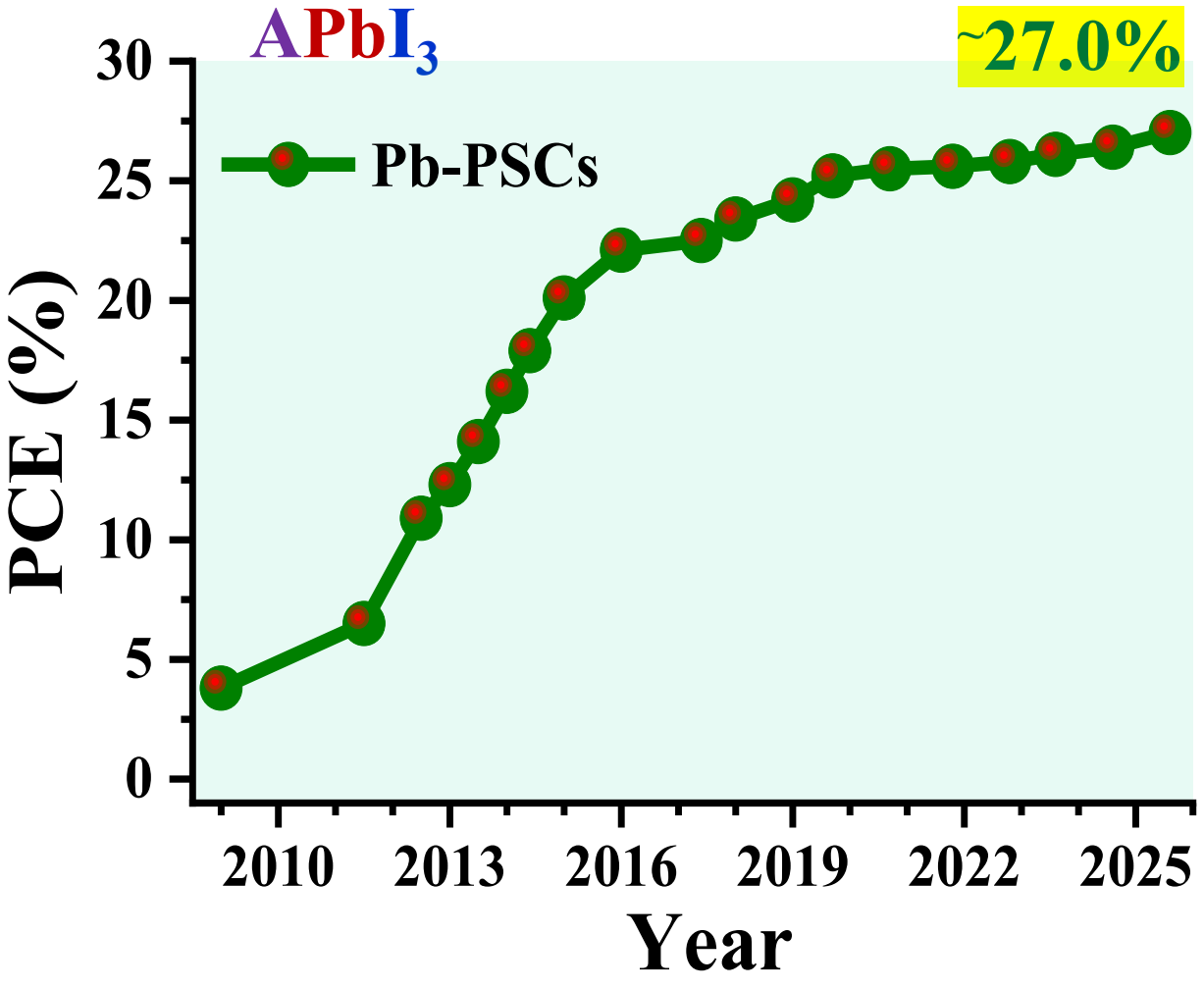
GPVC 2025
Global Photovoltaic Conference 2025
KPVS
September 1(Mon)-3(Wed), 2025
Daejeon Convention Center(DCC),
Daejeon, Korea

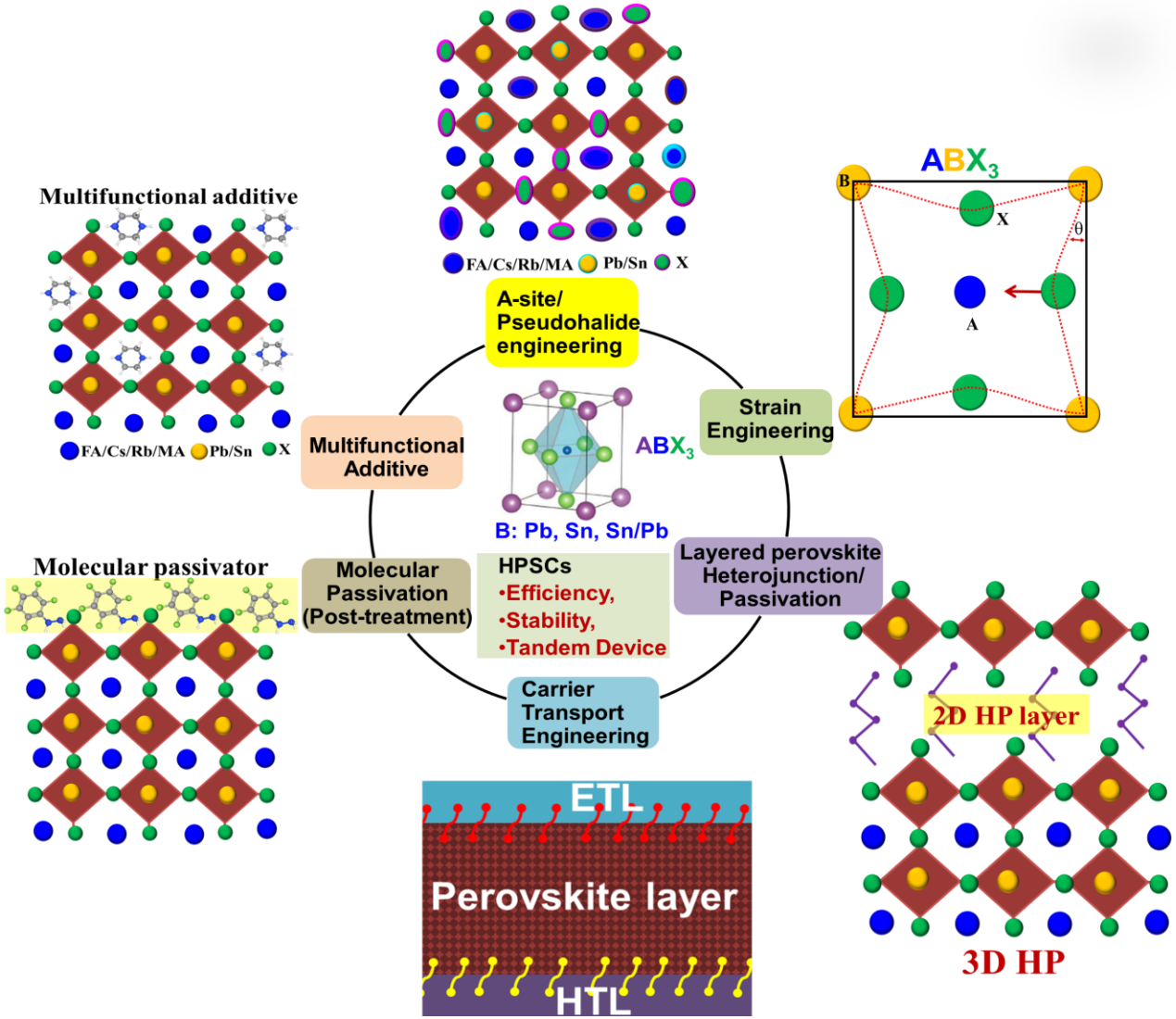
Perovskite Solar Cells With Terpyridine-zinc(ii) Coordination Nanosheets (CONASH) Additive

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Photovoltaic Materials Group
Global Research Center for Environment and Energy based on Nanomaterials Science(GREEN)
National Institute for Materials Science (NIMS), Tsukuba, Japan

Device efficiency progress and stability

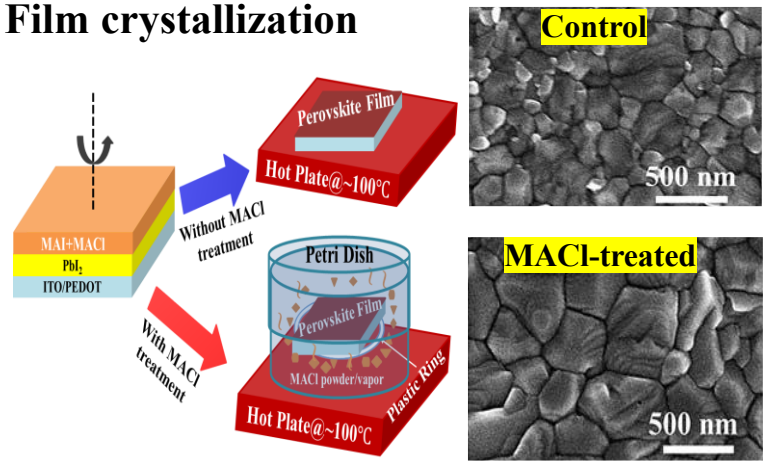


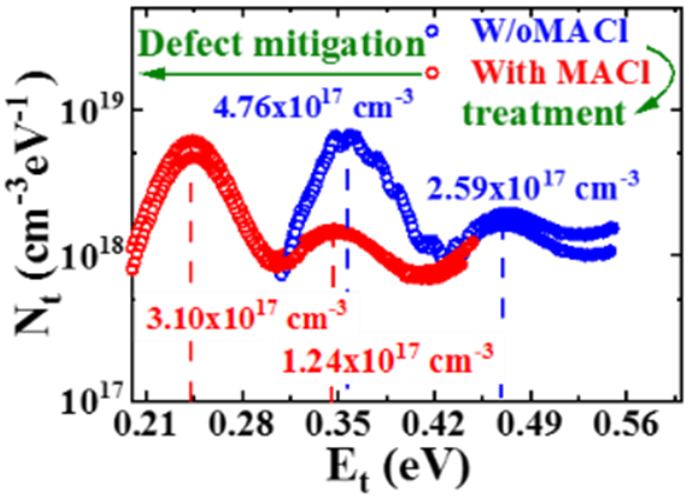


Khadka et al. Sol. RRL 2023, 2300535 (review article)

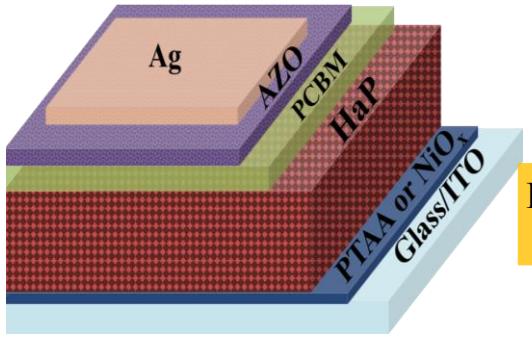
Our-reports-PSCs- device engineering

Film crystallization

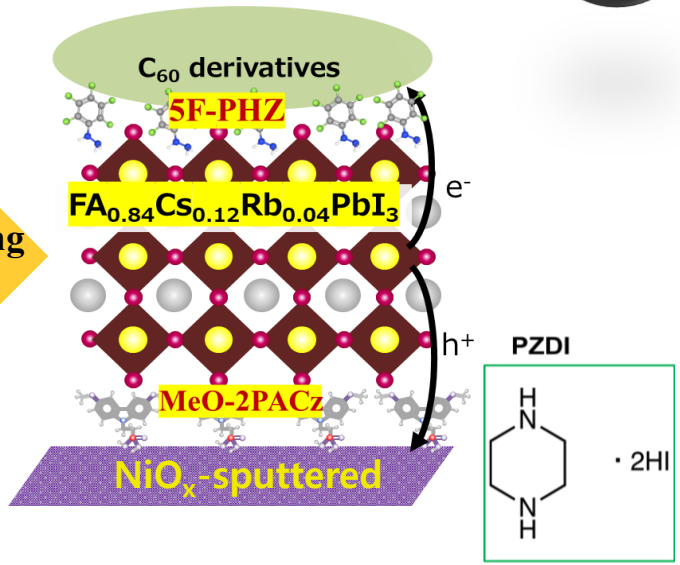


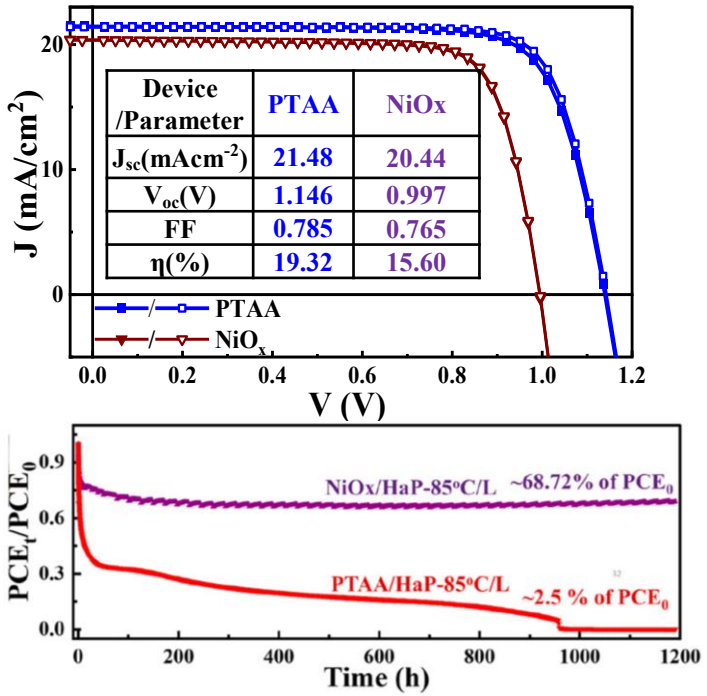


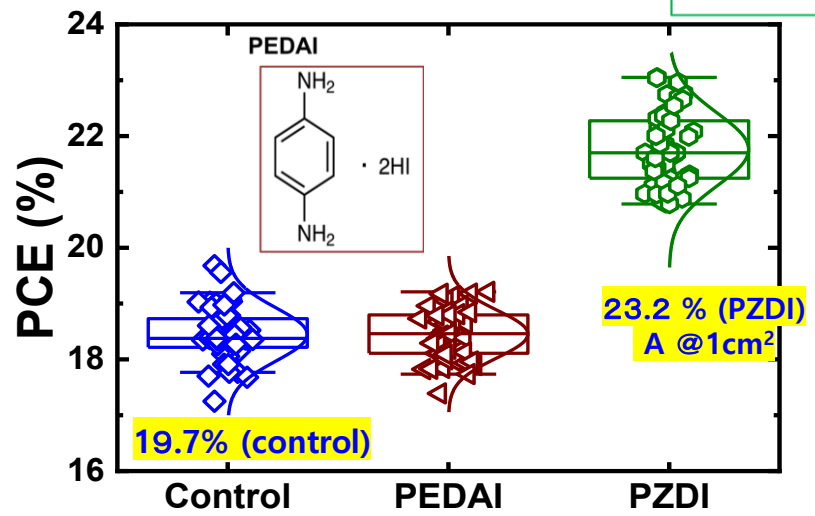
Khadka et al., Sustain. Energy Fuels, 2017, 1, 755



HTL/ETL- engineering – MA-free PSCs







- Khadka et al. ACS Appl. Energy Mater. 2021, 4, 10, 11121
- Khadka et al. ACS Appl. Mater. Interfaces, 2018, 11, 7055
- Khadka et al, ACS Appl. Mater. Interfaces, 2018,10, 22074
- Khadka et al., J. Mater. Chem. C, 2018, 6, 162-170

Khadka et al. Adv. Energy Mater. 2022, 12, 2202029

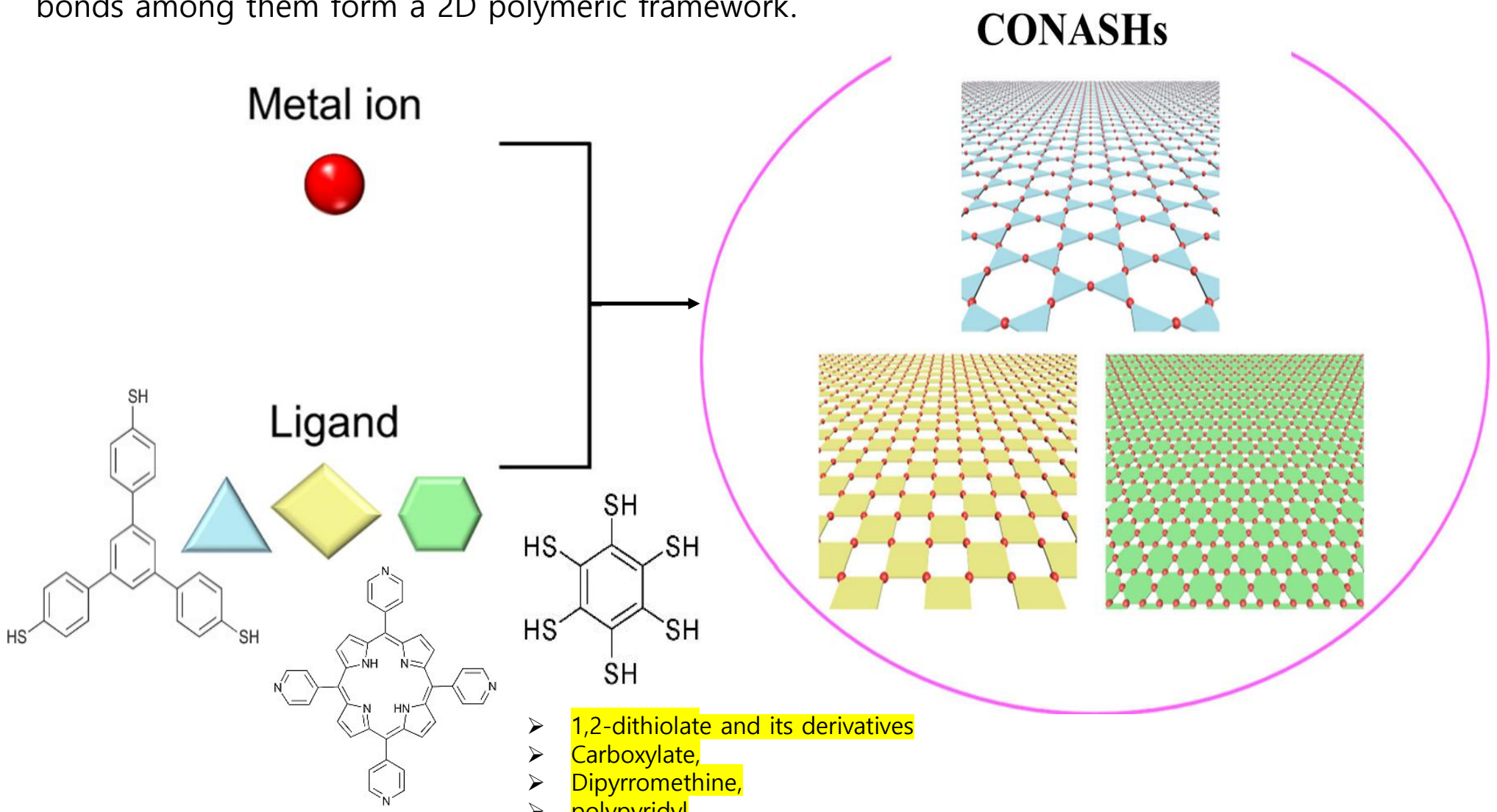
Khadka et al. Nat Commun 15, 882 (2024)

Coordination nanosheets (CONASHs)

Coordination nanosheets (CONASHs)

>Molecule-based nanosheets.

>Organic ligand molecules and metal ions/atoms/clusters, and the coordination bonds among them form a 2D polymeric framework.



- 1,2-dithiolate and its derivatives
- Carboxylate,
- Dipyrromethine,
- polypyridyl

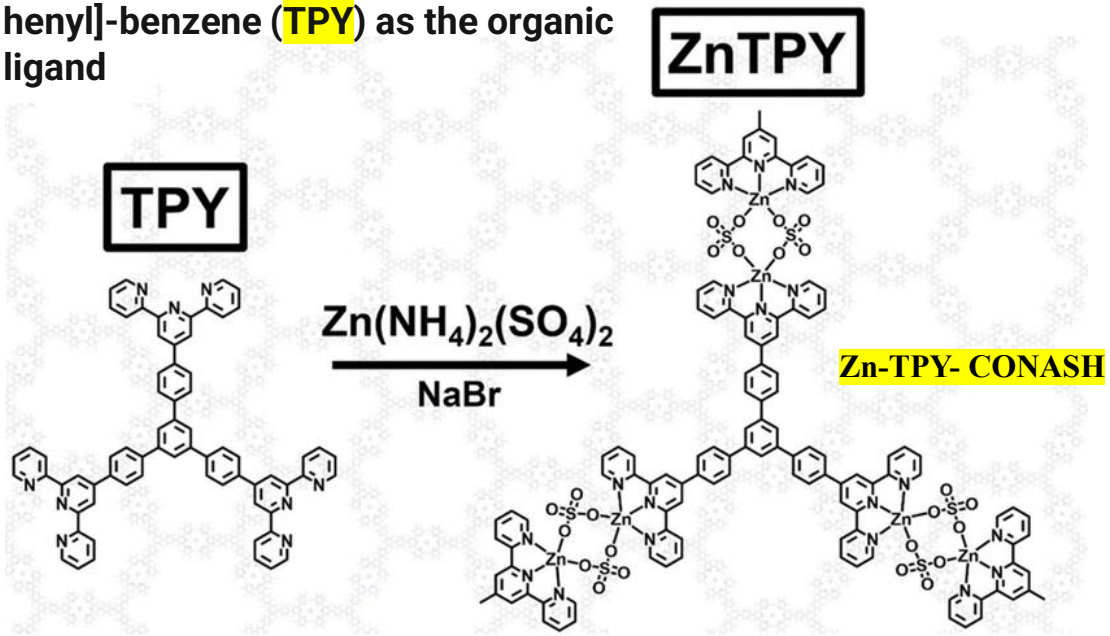


Hiroshi Nishihara

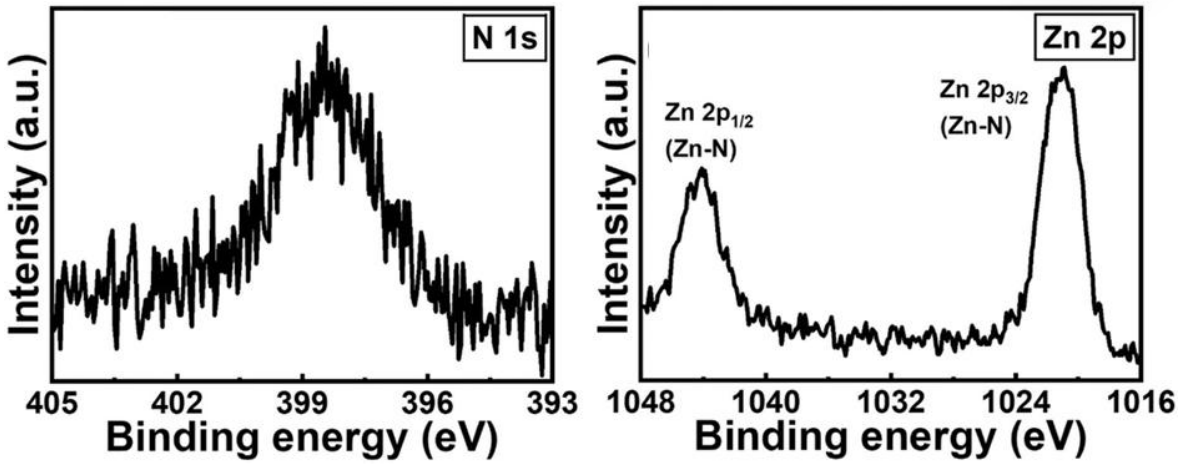
Hiroshi Nishihara and coworkers, Chem. Commun.,2017, 53,5781

Zn-TPY-CONASH-Synthesis

1,3,5-tris[4-(4'-2,2':6',2"-terpyridyl)phenyl]-benzene (TPY) as the organic ligand

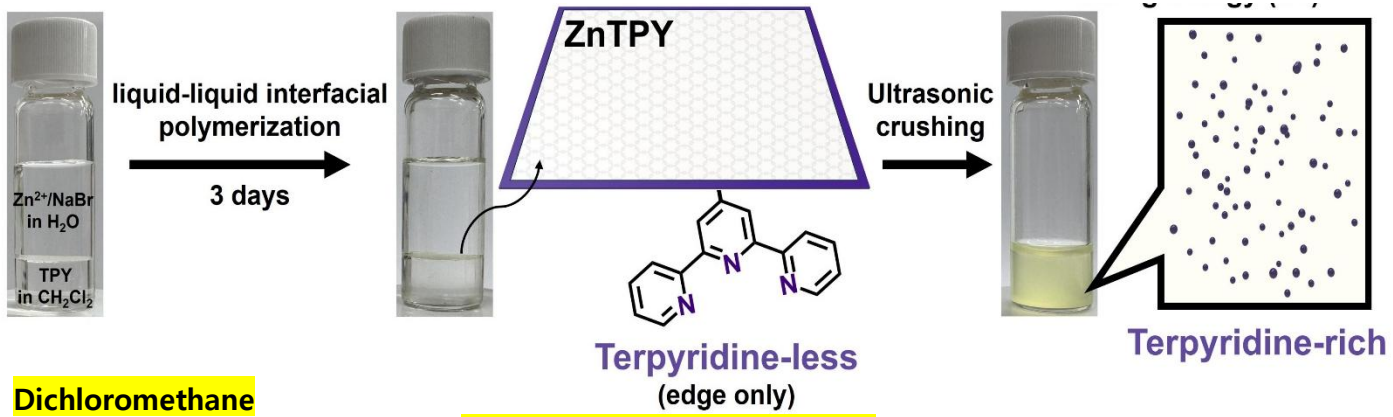


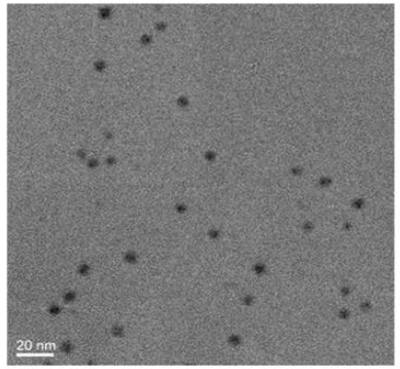
XPS spectra of as-synthesized ZnTPY CONASHs
>N 1s and Zn 2p core levels



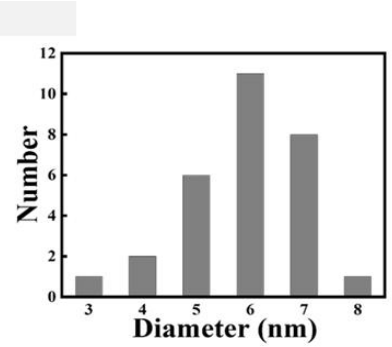
> Successful formation of ZnTPY CONASHs

- Liquid/liquid interfacial synthesis



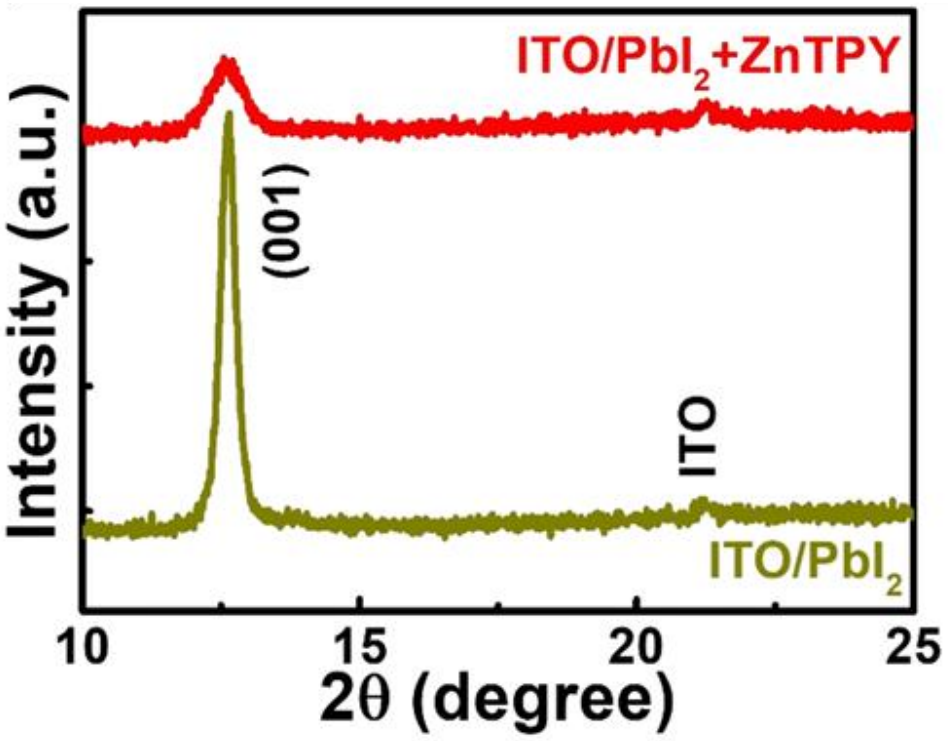


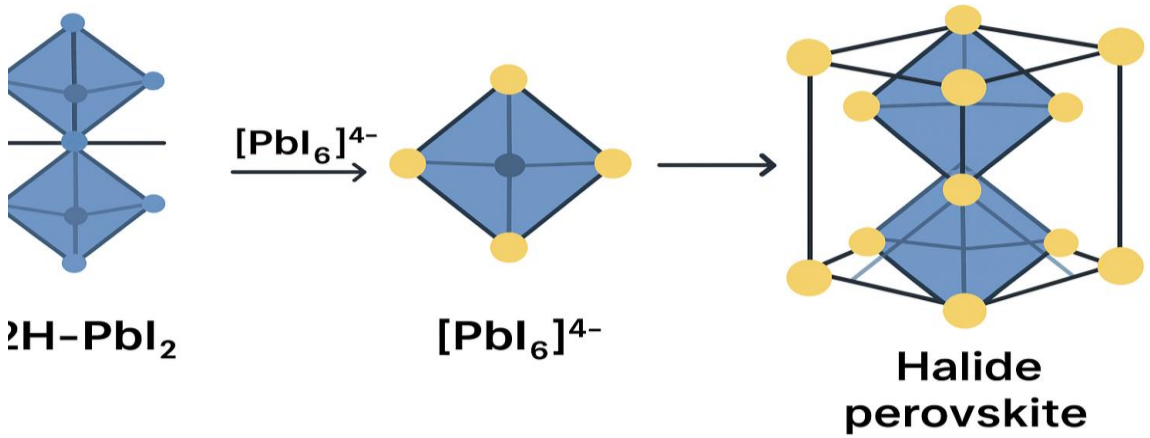
TEM image



Growth of CONASH/Halide Perovskite

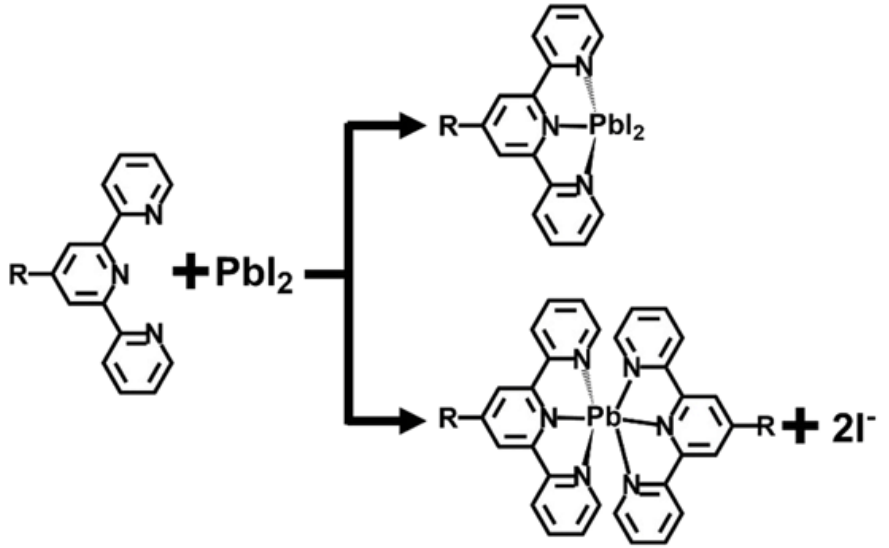
XRD- PbI_2 and Zn-TPY





$[(PbI_{6-x})^{4-}–ZnTPY]$

Two possible routes of the formation of Zn-TPY: PbI_2 adducts

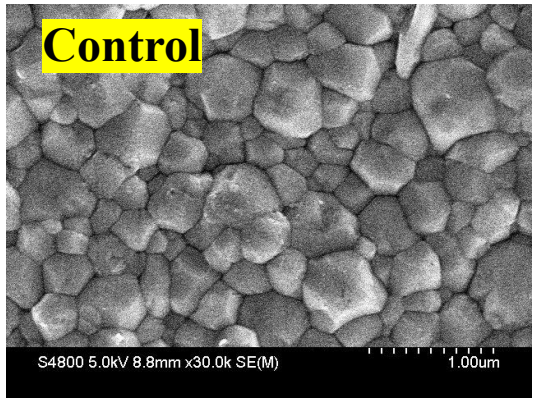


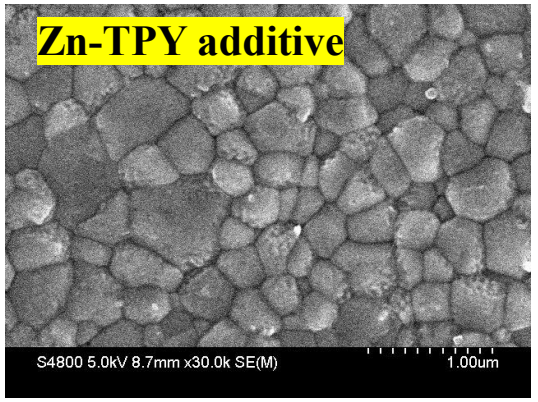
Diffraction peak-(001) – hexagonal 2H polytype PbI_2 Suppressed

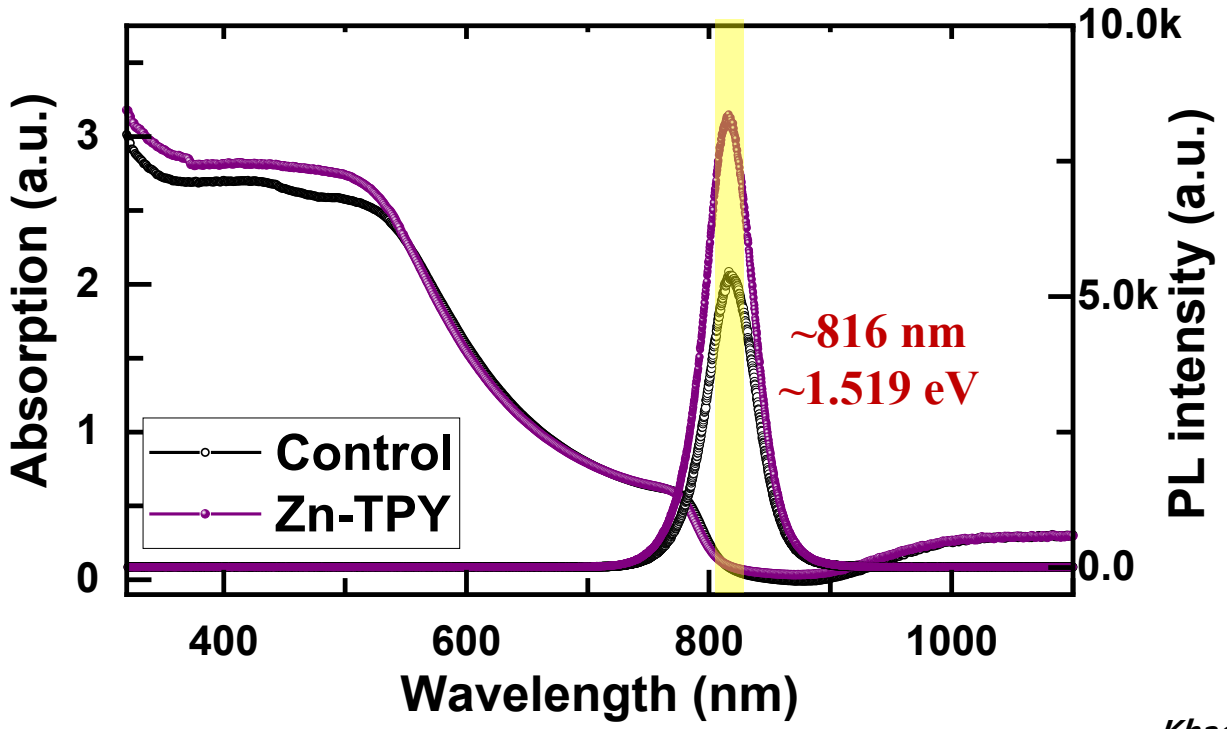
>Facile insertion of ZnTPY into PbI_2 aggregates through multidentate chelation.

Nishihara and co-workers, J. Mater. Chem. A,2023, 11,7077

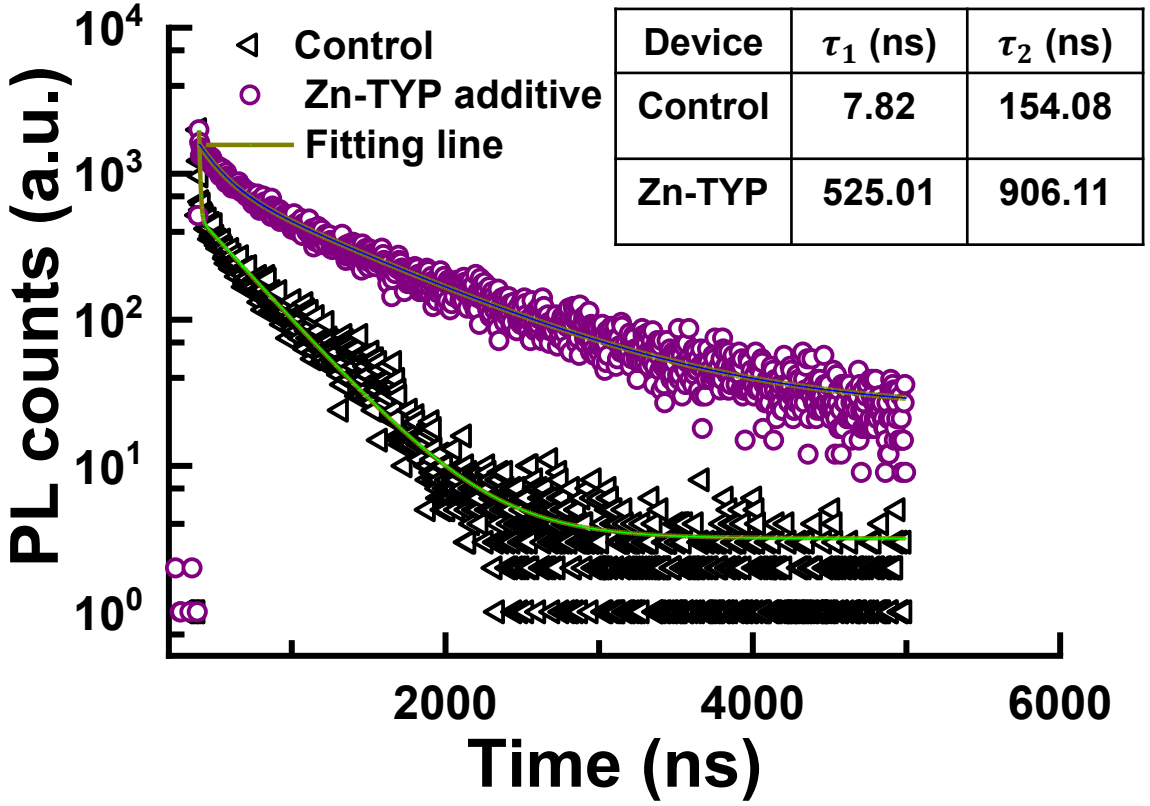
Effect of CONASH- Perovskite film







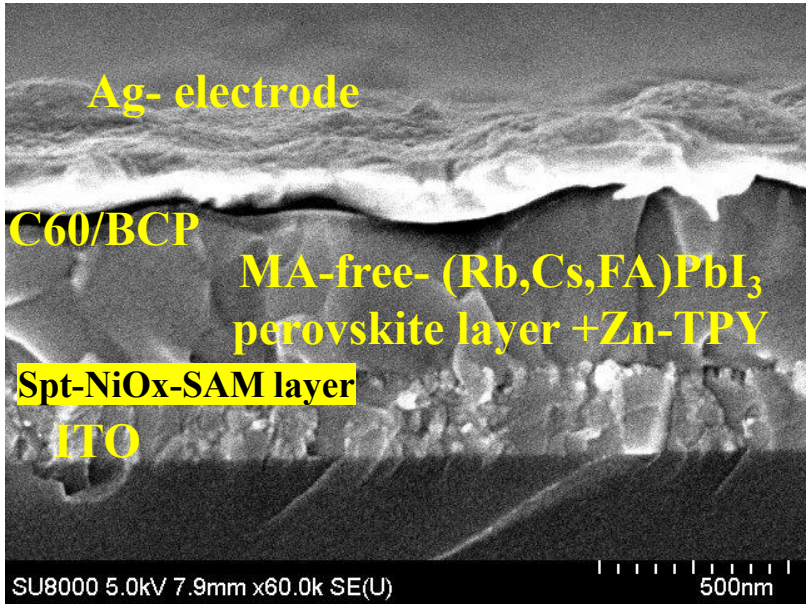
TRPL data

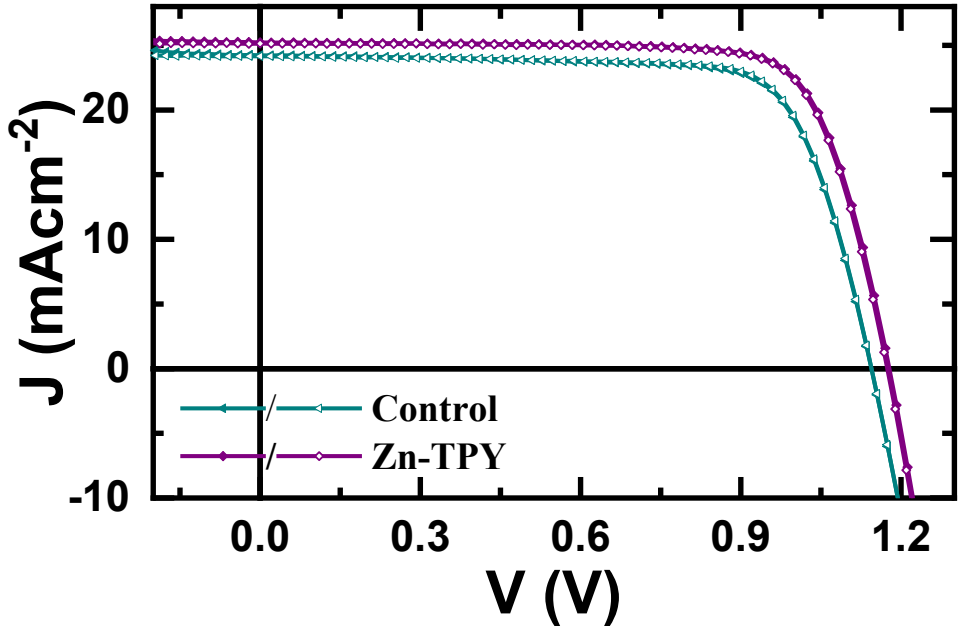


Device	τ_1 (ns)	τ_2 (ns)
Control	7.82	154.08
Zn-TYP	525.01	906.11

Khadka et al. under submission

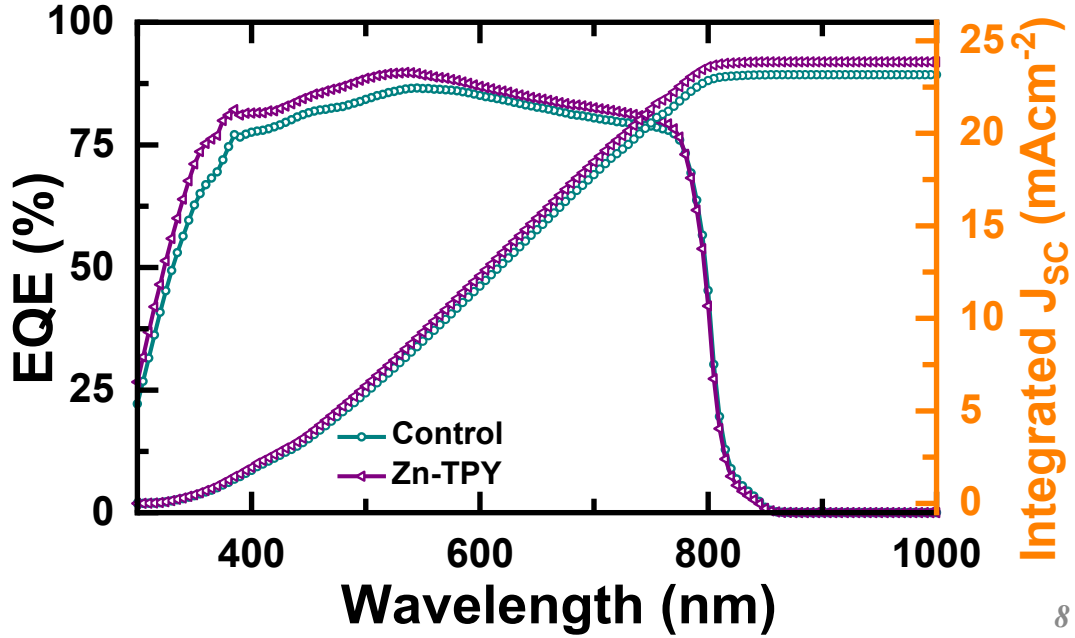
Effect of CONASH- Perovskite Device





PSCs	J_{SC} (mAcm^{-2})	V_{OC} (V)	FF	PCE (%)	PCE (%) ± SD
Control	24.23	1.148	74.87	20.83	20.05 ±0.55
Zn-TPY	24.95	1.180	76.78	22.60	21.62 ±0.52

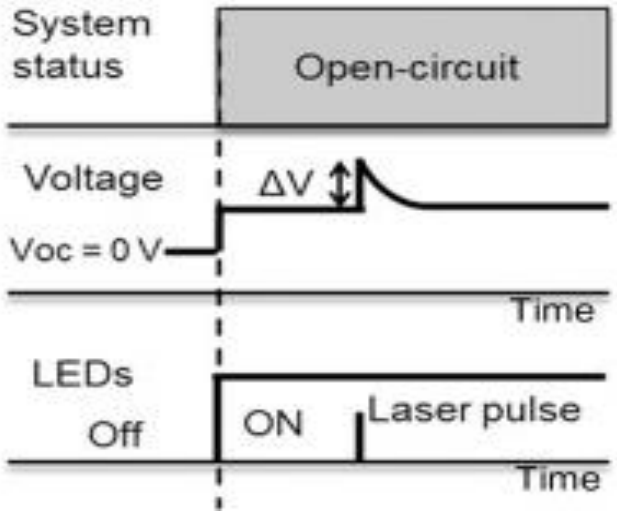
A- 1cm^2



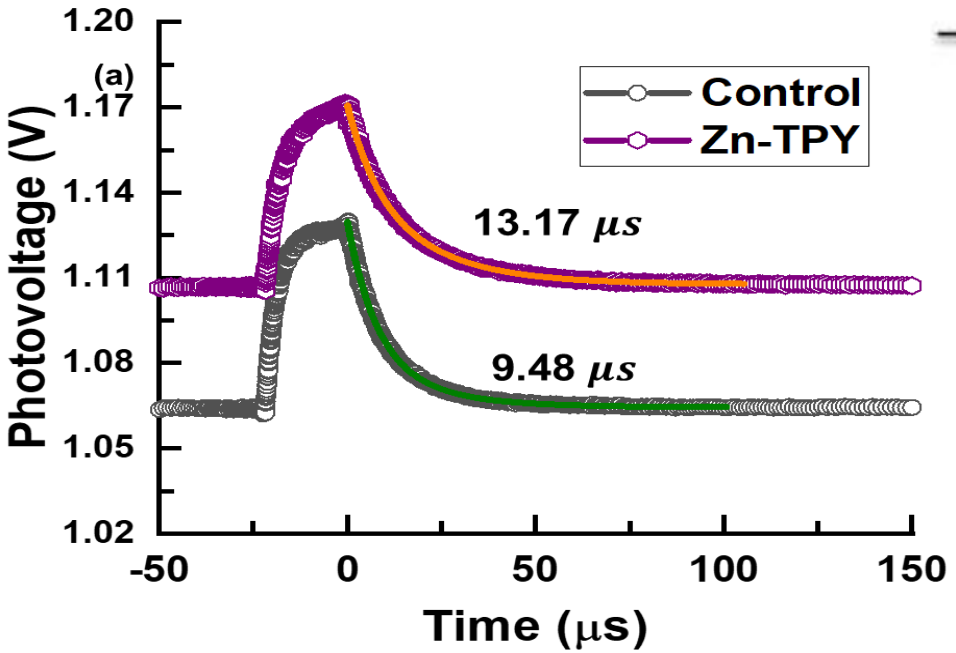
Khadka et al. under submission

Transient –photo characteristics -PSCs

Transient Photovoltage Analysis



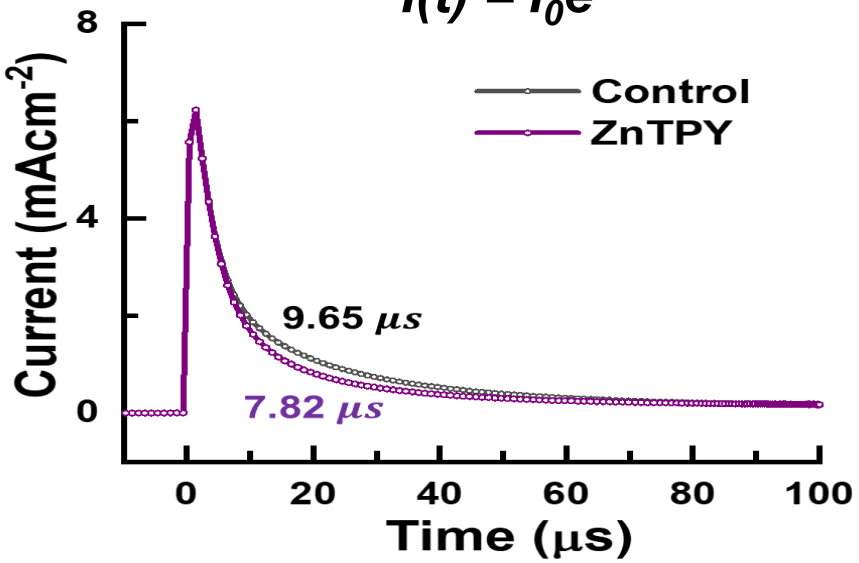
$$V(t) = V_0 e^{-t/\tau}$$



Longer lifetime: Defect mitigation

Transient Photocurrent Analysis

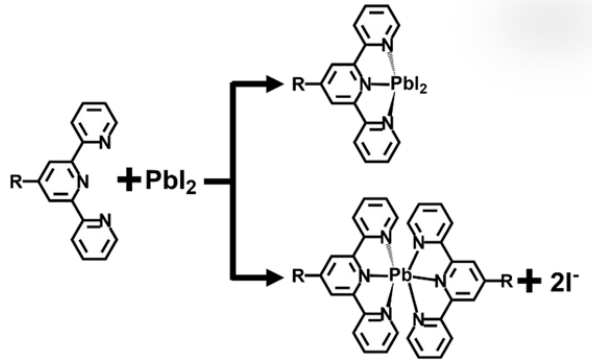
$$I(t) = I_0 e^{-t/\tau}$$



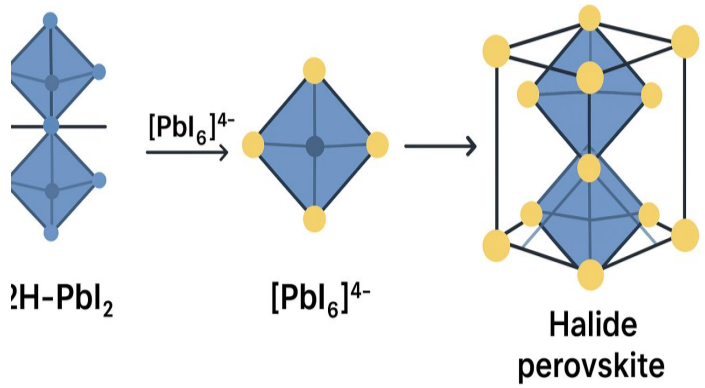
Faster carrier extraction > Better interface quality

Report Summary

Effects of CONASH in Perovskite Solar Cells



- **Precursor modulation:** Uncoordinated terpyridine moieties that strongly chelate PbI_2, forming a well-dispersed ZnTPY:PbI_2 complex
- **ZnTPY:PbI_2 complexes:** Heterogeneous nucleation ($[PbI_{6-x}]^{4-}$ octahedral) facilitates efficient precursor-to-perovskite film growth
- ***Defect passivation:*** ***Attenuate defect densities and enhance carrier dynamics***
- ***Device PCE increased- from 20.80 to > 22.6% - with improved stability***



Acknowledgement

- Hitachi Global Foundation, Kurata Grant (PI)
- Yazaki Foundation for Science and Technology: (PI)





Thank you for your attention