

University of Louisville
Department of Chemistry
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Literature Seminar

When: October 30, 2023

Time: 3:00 p.m.

Location: CBLL-16

2D/3D Heterostructure Perovskite Solar Cells

Abstract:

Perovskite solar cells are an emerging technology with remarkable power conversion efficiency and a low-cost fabrication process. Organic-inorganic hybrid perovskite materials make efficient photovoltaics due to their unique structure and favorable optical properties. The general formula for organic-inorganic hybrid 3D perovskites is ABX_3 , where A is an organic cation, B is a divalent metal cation and X is a halide ion. Unfortunately, 3D metal halide perovskites are susceptible to degradation upon exposure to moisture and UV light. One approach being developed to improve the stability of perovskite solar cells is to incorporate 2D perovskite material into the 3D perovskite composition. The lower dimensionality 2D perovskites are composed of alternating larger-size organic cations and inorganic layers. The large organic cations are selected to increase the hydrophobic character of the material, locally repelling water and enhancing the stability against moisture. However, purely 2D perovskite solar cells generally exhibit poor power conversion efficiency, in part because they typically have wide band gaps. Also, in a 2D perovskite, the long-chain organic cations inhibit charge transport across their insulating carbon backbone. To achieve a more ideal band gap and simultaneous high stability in a metal halide perovskite, researchers are pursuing novel compositions of 2D/3D heterostructures. $A'_nA_{n-1}B_nX_{3n+1}$ is the general formula for mixed-dimension, mixed-cation, metal halide perovskites in which A' indicates a large size cation and A is a smaller size cation. For 2D perovskites, state-of-the-art compositions have used conjugated organic ammonium groups, such as phenyl ethyl ammonium, and the presence of delocalized π electrons in a related conjugated molecule allows for easier charge conduction. Methyl ammonium is the most common organic cation in 3D perovskites. Recent literature reports show that mixed 2D/3D heterostructure perovskites are capable of enhanced stability and power conversion efficiency and could thus play a crucial role in the advancement of sustainable and clean energy production.

References:

1. Krishna, Anurag, et al. "Mixed dimensional 2D/3D hybrid perovskite absorbers: the future of perovskite solar cells?." *Advanced Functional Materials* 29.8 (2019): 1806482.
2. Campos, Thomas, et al. "Unraveling the Formation Mechanism of the 2D/3D Perovskite Heterostructure for Perovskite Solar Cells Using Multi-Method Characterization." *The Journal of Physical Chemistry C* 126.31 (2022): 13527-13538.
3. Song, Zonglong, et al. "Inverted Wide-Bandgap 2D/3D Perovskite Solar Cells with > 22% Efficiency and Low Voltage Loss." *Nano Letters* 23.14 (2023): 6705-6712.