Interface-engineered materials For High-efficiency All-organics Solar Cell

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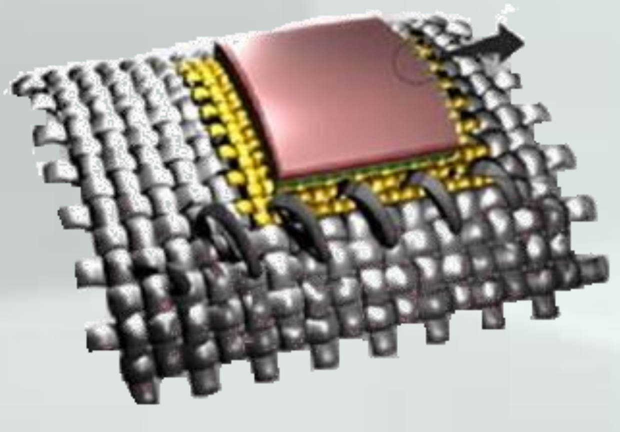
NEBRASKA CENTER FOR ENERGY SCIENCES RESEARCH

Photovoltaics from Organics



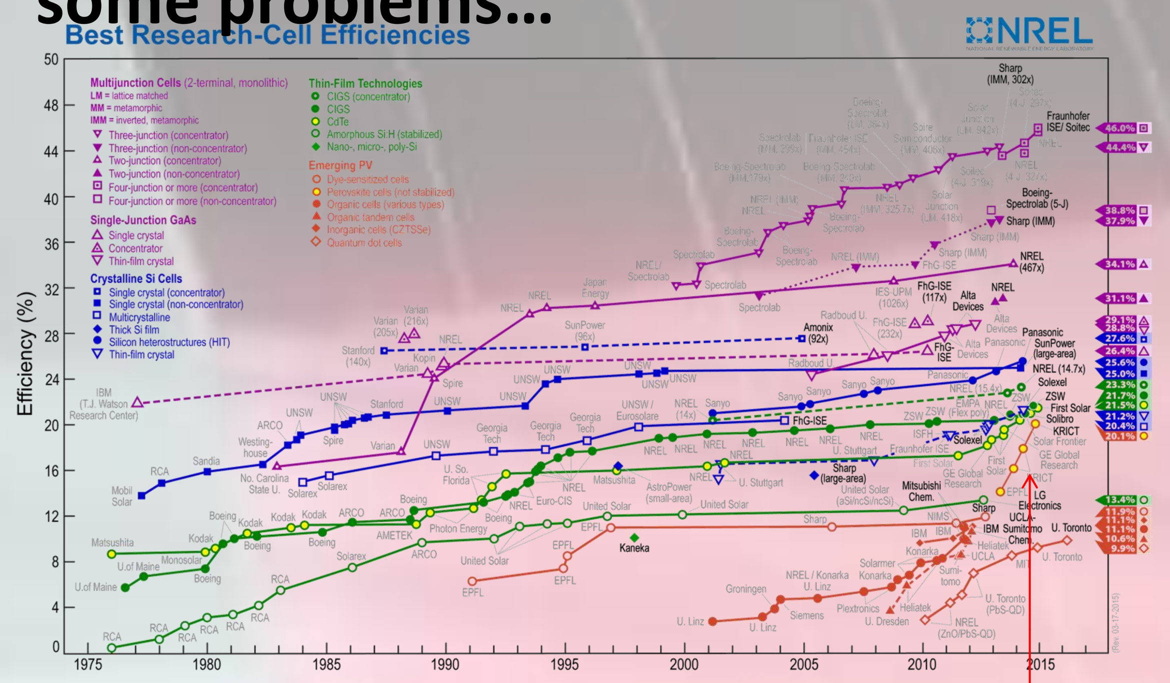
Advantages of organic electronics:

- cheap
- flexible
- bendable
- amenable to a variety of high throughput production methods

Problems with Organic Photovoltaics

- Organic solar cells need to stable! They have to work for a long, long time and survive in harsh conditions.
  - solution: need additives to stabilize the organics
- They need to be made more efficient! Now efficiency is low (about 5%) or high (23%) but in materials not very stable. (high efficiency materials that degrade in sunlight)
  - solution: need additives to stabilize the organics – these will be dipolar molecules, and graded multilayers could improve efficiency a lot
- The organic solar cells need to be scalable! Can the materials be manufactured cheaply on a large scale?
  - Solution: Deposition from solution

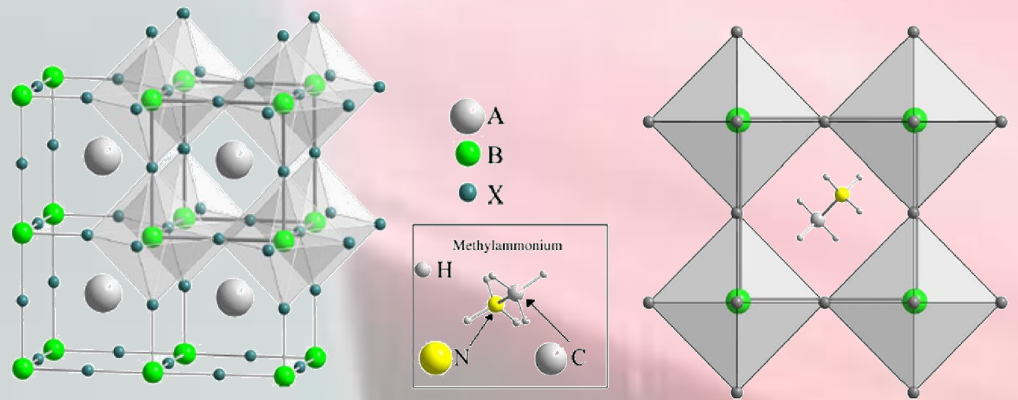
Organic Photovoltaics are emerging and promising, with some problems…



Red are the organic solar cells

And these are not very stable

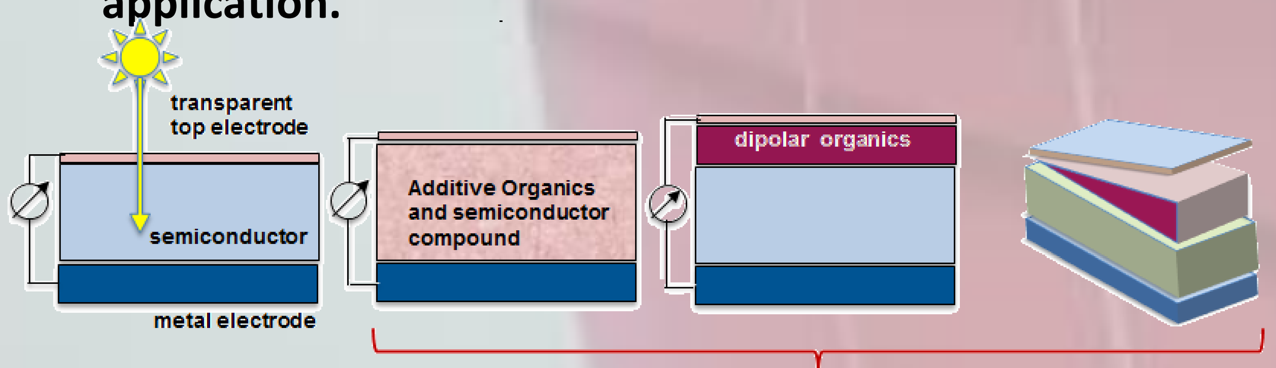
organolead trihalide $CH_3NH_3PbX_3$
(organic perovskite)



D. Shi, Peter A. Dowben, O. M. Bakr, et al, "Exceptionally low trap-state density and long carrier diffusion in room-temperature grown $MAPbBr_3$ perovskite single-crystal wafers", *Science* 347 (2015) 519-522

Goals, Objectives and Approach

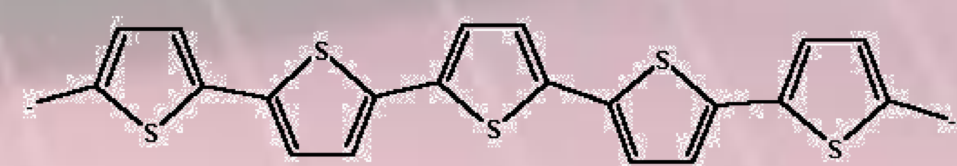
- Characterization of novel dipolar molecules for enhanced OPV current generation and charge extraction
- Better stabilization of the metal organic hybrid organo-lead trihalide, $CH_3NH_3PbX_3$, perovskite solar cell materials
- Developing protocols for the large-scale fabrication of organics-based hybrid lyers for photovoltaics application.



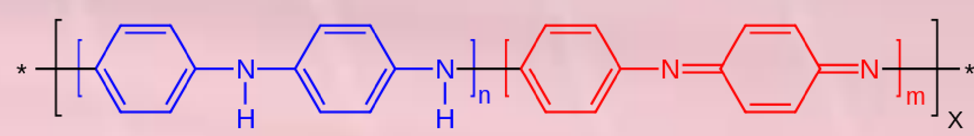
Standard PV device structure

Modifications pursue by the PI

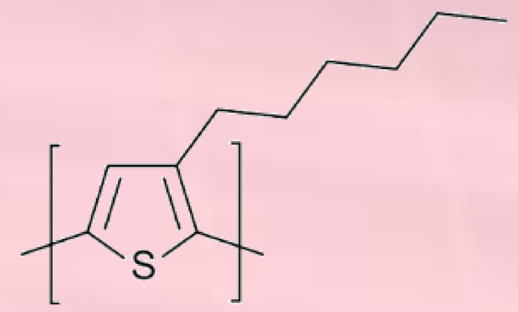
Organic Semiconductors and Materials selected for this systematic study:



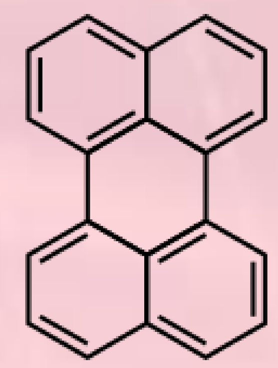
Polythiophene



Polyaniline

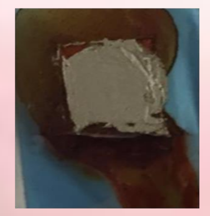
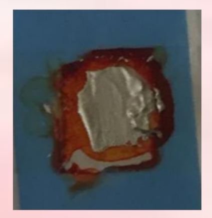
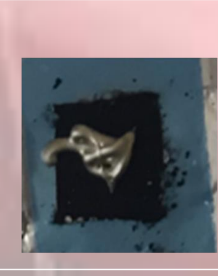
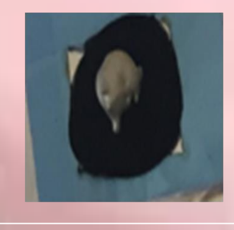
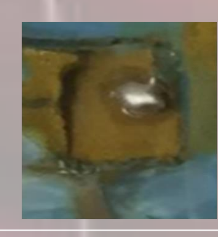


Poly(3-hexylthiophene-2,5-diyl)
P3HT



Perylene

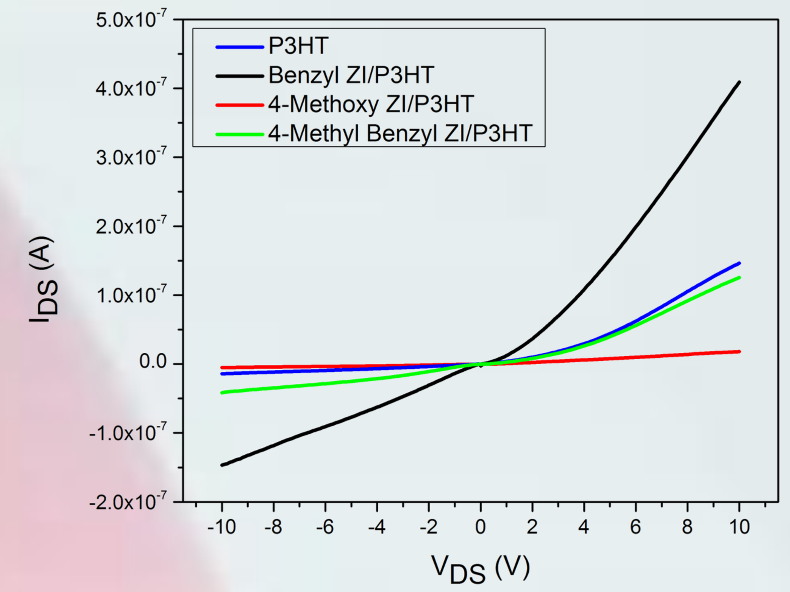
Rapid Screening of Materials Combinations

Ratio of organic semiconductor to Zwitterion	1:1	10:1
P3HT:ZI(parents)		
Polyaniline:ZI(parents)		
Perylene:ZI(parents)		

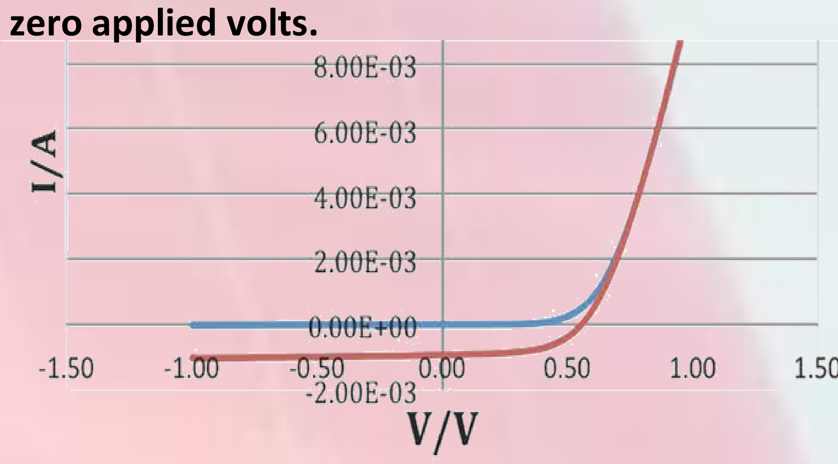
We are establishing the ideal mixing ratio of organic semiconductor to zwitterion additive that gives best photovoltaic efficiency, in a rapid prototyping approach.

Demonstration of Additives on PV Performance

Addition of dipolar molecular additives (zwitterions) to a semiconductor organic polymer, P3HT, changes I-V characteristics in a broad range, from insulating to semiconducting to metallic

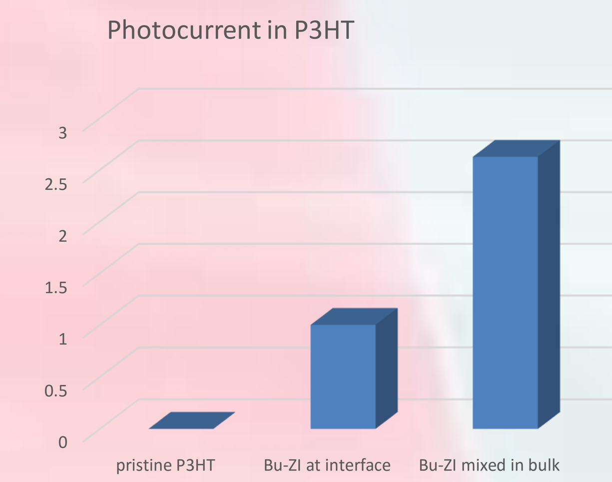


The signature of a successful organic solar cell combination: current at zero applied volts.



Enders, Dowben, and Doudin; unpublished data for dipolar zwitterion molecule (where R = C4H9) in combination with the organic semiconductor PEDOT (Poly(3,4-ethylenedioxythiophene).

The additives enhance photo current generation!
But:
We still need to increase this current generation!



Dipolar molecules produce an intrinsic electric field that enhances the electron-hole separation in the semiconductor. This is new science!

Outcome and Impact

Within the funding period we expect
To start a "Materials Genome" type rapid prototyping of materials for organic photovoltaics
To identify promising combinations of organic semiconductors and additives for improved OPV efficiency
To identify promising additives that improve the stability of organo-led trihalides
To file a patent, and to submit major grant applications