ORGANIC PHOTOVOLTAICS

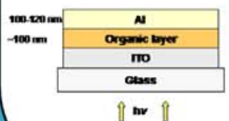
Z. I. Niazimbetova (PD), E. Peng (BSMSE), R. Beyer (ARL) and M. E. Galvin

University of Delaware • Center for Composite Materials • Department of Materials Science & Engineering

INTRODUCTION

- Conventional inorganic photovoltaic cells – efficient but expensive
  - High vacuum and high temperatures required for processing inorganic photovoltaics
- Organic photovoltaics offer
  - Cheap processability
  - Large area coating possible at low temperatures
  - Low overall costs, low weight and mechanical flexibility
  - Transparent cells which suggest extensive use in windows, roof lighting, and automotive sun roofs

ORGANIC PHOTOVOLTAIC DIODE



- Absorption of light create an exciton
- Dissociation of the exciton into carriers
- Transport carriers to electrodes
- Collect and store current
- This process is driven by the internal field due to work function difference of the different metal electrodes

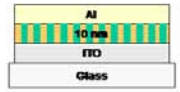
HETEROJUNCTION DEVICE

- Simple heterojunction doesn't work well

exciton diffusion too short – can only split at organic/ organic junction

Tang (*Appl. Phys Lett.* 48, 183, 1986. Power eff. = 1% (AM2)

Forrest – Power conversion. eff. of 2.5% and VOC = 1.3 via stacking 3 heterojunctions – evaporated organics



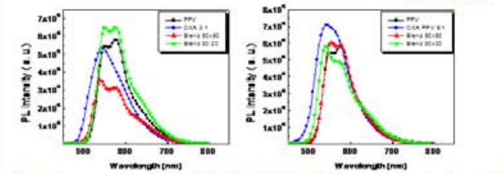
- Solution – control morphology – blend with bicontinuous phases for holes and electrons

ORGANIC PHOTOVOLTAIC: CHALLENGES

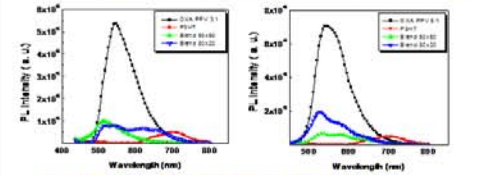
- Matching the solar spectrum
- Increase mobility
- Increase lifetime and stability
- Develop new coating techniques for organics for large area applications

PHOTOLUMINESCENCE STUDIES – Quenching Effect

Exc. 425 nm



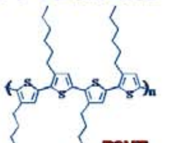
Emission spectra of OXA-PPV 3:1, 5:1, P3HT and blends from film



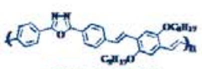
Studying PL – tells if exciton has been split (PL quenched).
If radiative charge recombination is quenched – photo current can be expected. Efficient separation of excited states results in luminescence quenching.

CONJUGATED POLYMERS

PPV



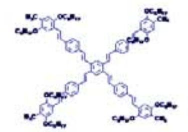
P3HT



OXA PPV 3:1

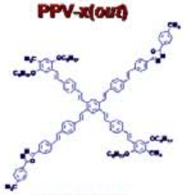
OXA PPV 5:1

2D OLIGOMERS



PPV-x(*out*)

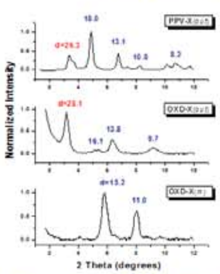
- Charge carriers are delocalized in two or three dimensions
- Some interesting possibilities for improvement of mobility and physical properties
- Solvent processable



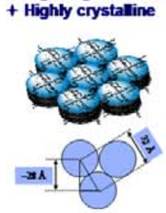
OXA-x(*out*)

OXA-x(*in*)

X-RAY STUDIES



- Sharp Bragg peaks
- High degree of order
- Highly crystalline



The peaks at 3.34 for PPV-X(*out*) and 3.14 for OXD-X(*out*) correspond to d-spacing of 26.25 Å and 28.14 Å respectively and may be related to inter-columnar distance between π-π stacked molecules.

CONCLUSIONS

- Synthesized and characterized conjugated polymers for use in PV devices
- PL studies of linear polymers with different blend ratios performed
  - Blend of OXA PPV with P3HT showed quenching effect
- Synthesized 2D-oligomers for PV application
  - They are thermally stable, highly crystalline, high degree of order

FUTURE WORK

- PL studies of 2D oligomers
- Electrochemistry
- Device fabrication
- Device morphology

ACKNOWLEDGEMENTS

This work is supported by the Army Research Laboratory through the Composite Materials Research program.