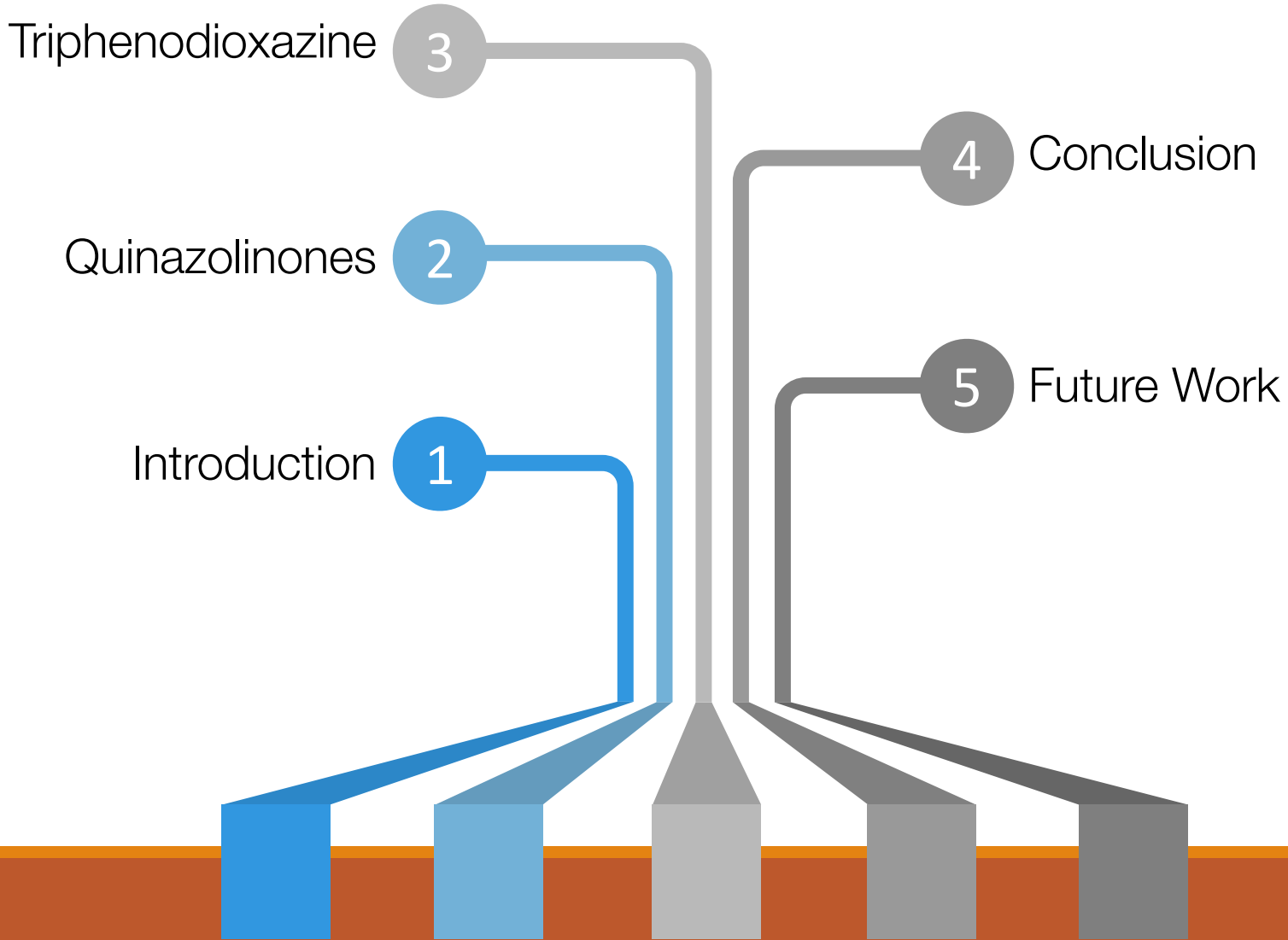
Nature Inspired Polymers: Promising Materials for OTFT-Based Sensing

BY:JESSE QUINN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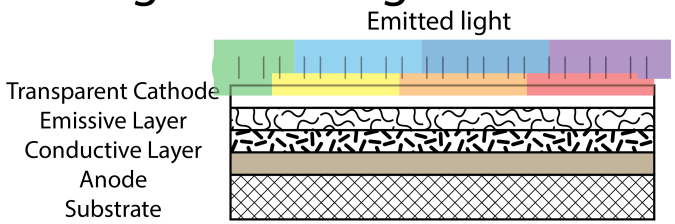
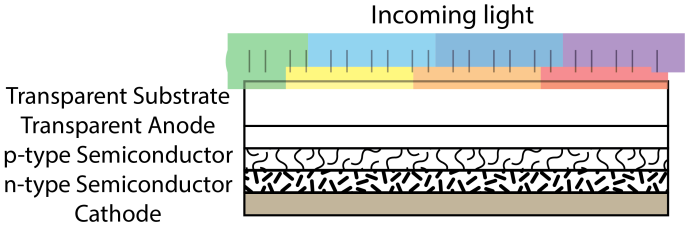
Future Work

Organic Electronics

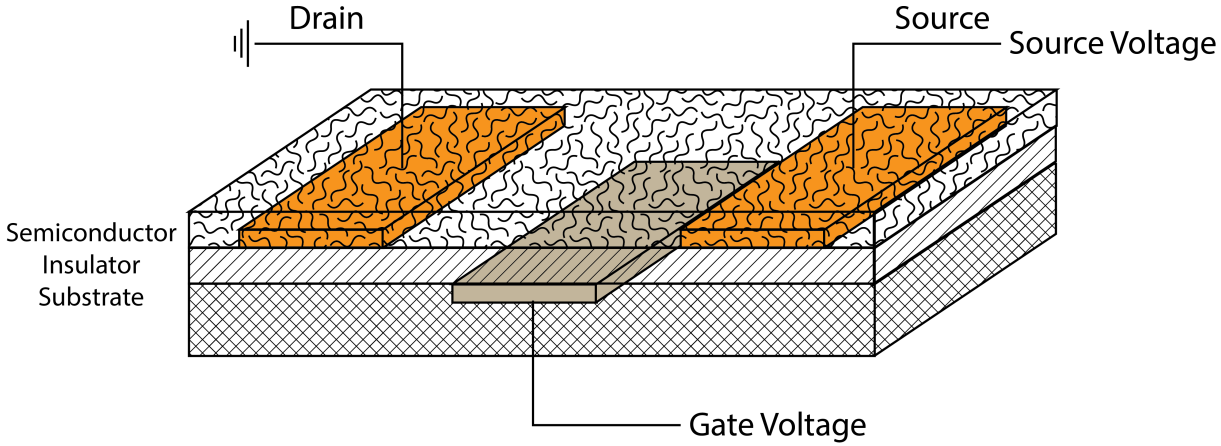
Light Emitting Diode



Photovoltaic Cell



Thin-Film Transistor



Background

TREND OF ORGANIC SEMICONDUCTOR AND ELECTRONICS RESEARCH

A race for high mobility, on-off current ratios, PCEs, FF, etc..

Shorting coming has been air stability…

Fabrication/processing/characterization typically in inert atmosphere to demonstrate key merits!

CAVEATS OF ORGANIC SEMICONDUCTORS

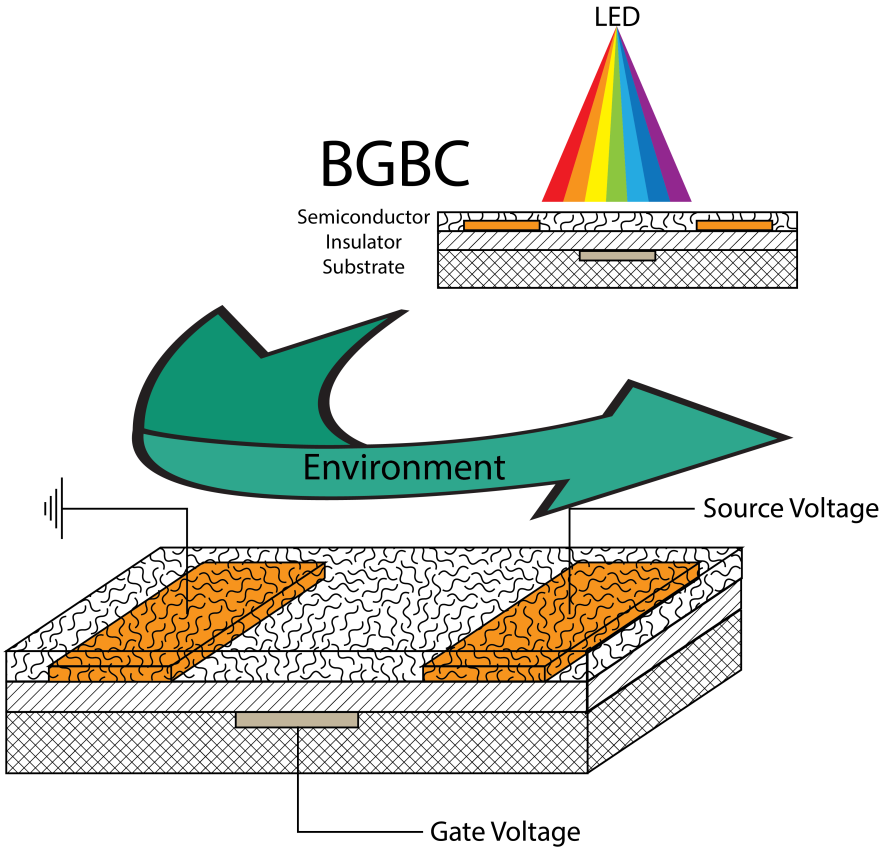
OSCs by their very nature are sensitive..

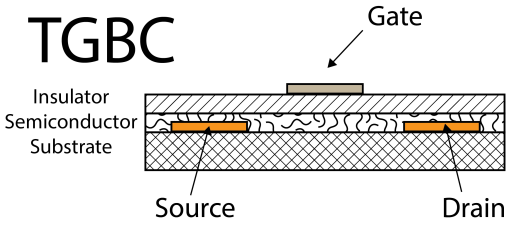
Photo-induced excitation

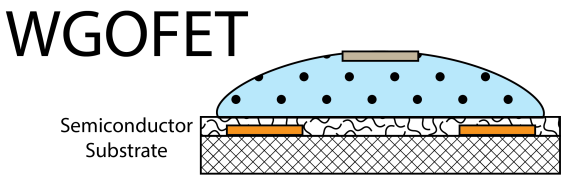
Doping/trapping occurs with the presence of oxygen, moisture, carbon dioxide, etc.

Can this intrinsic sensitivity be harnessed?

Device Architectures



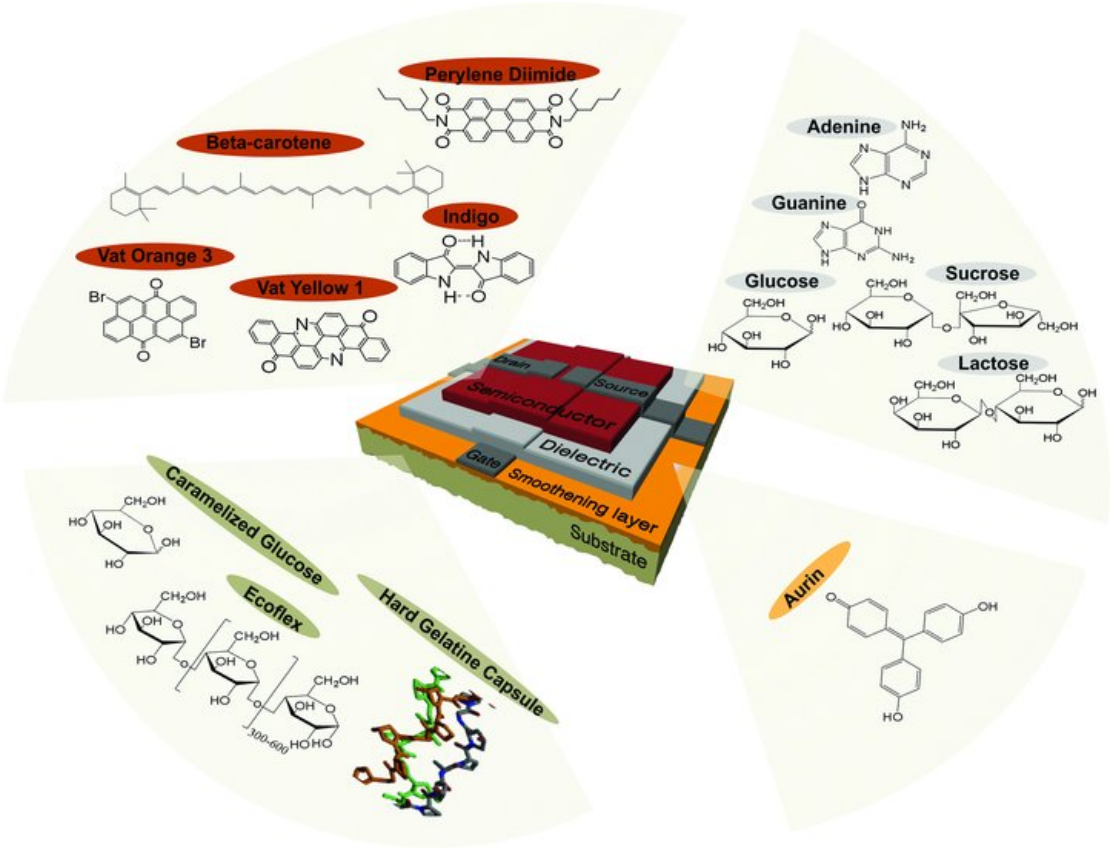




Goals and Limitations

- Selectivity
- Calibration range
- Sensitivity
- Precision
- Accuracy
- Limits of detection and quantification
- electronic output signal (transduction)
- high sensing performance level
- low-cost fabrication

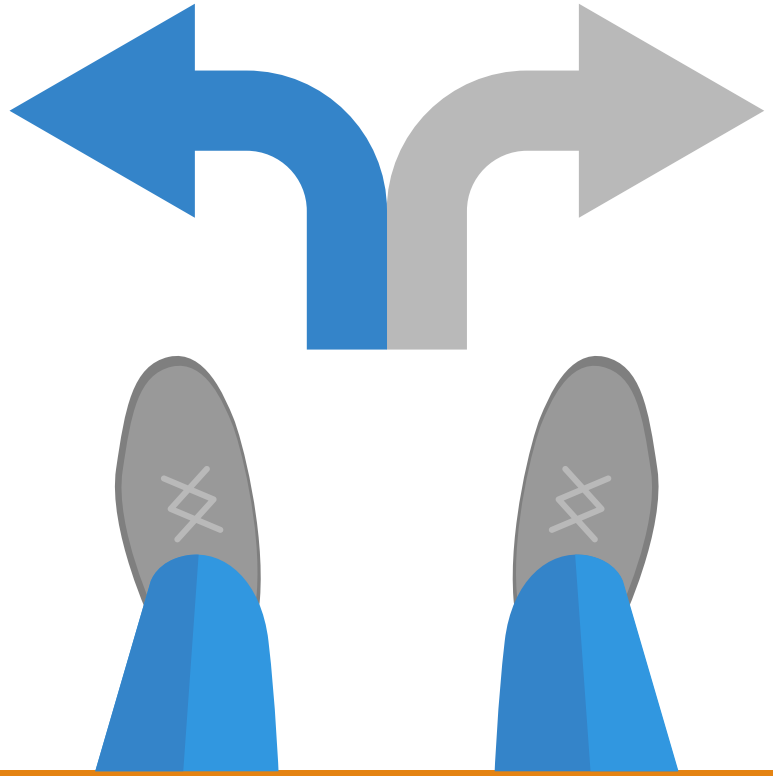
Natural/Nature Inspired



M. Irimia-Vladu *et al.*, *Adv. Funct. Mater.*, 2010, **20**, 4069–4076.

Quinazolinones

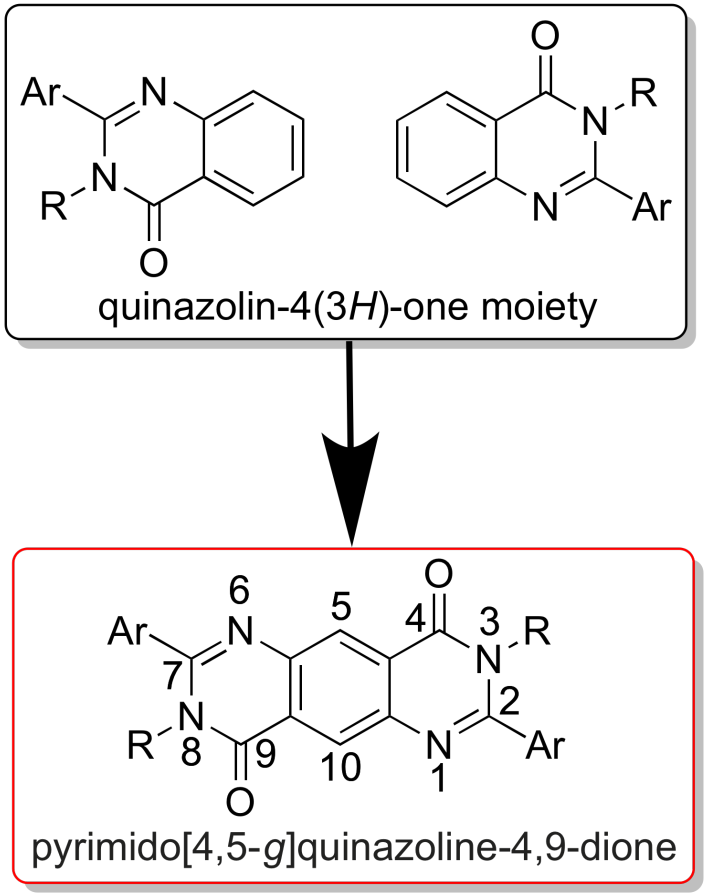
Naturally occurring and can be found in over 150 alkaloids. They are actively studied as they represent an important class of compounds due to their wide range of intrinsic biological activities.

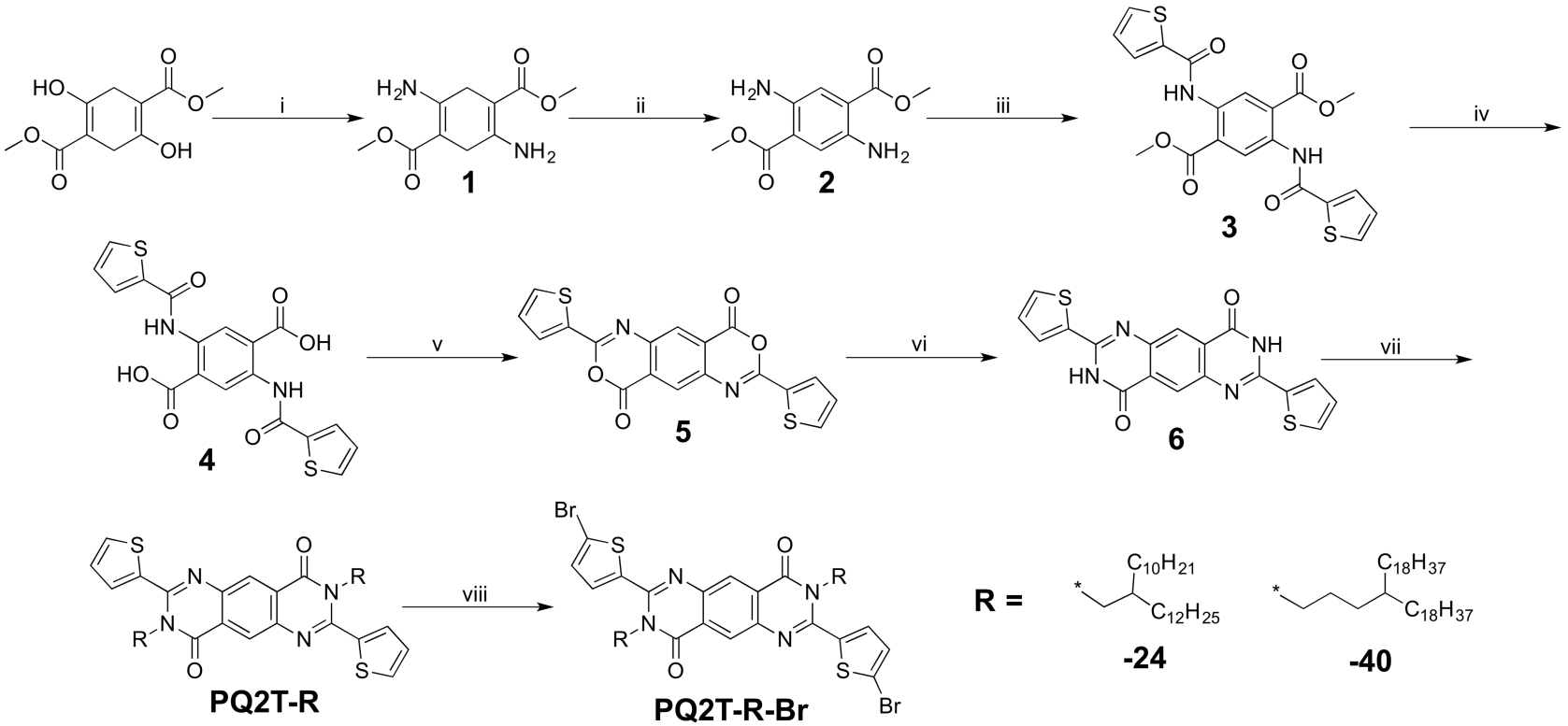


Triphenodioxazines

Core structure of several commercial dyes and pigments. Not naturally occurring, but reflects upon the long-term research aim to produce good brightness and fastness properties compared to naturally derived dyes and pigments.

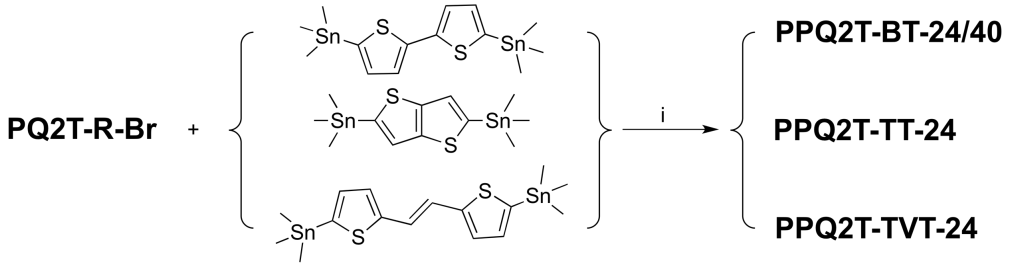
Quinazolinones

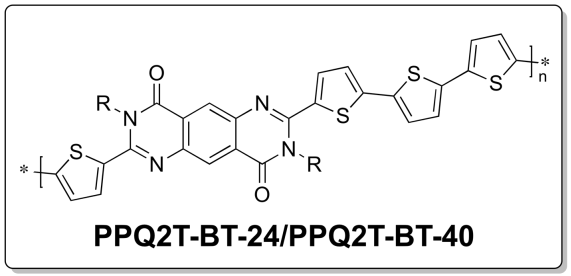


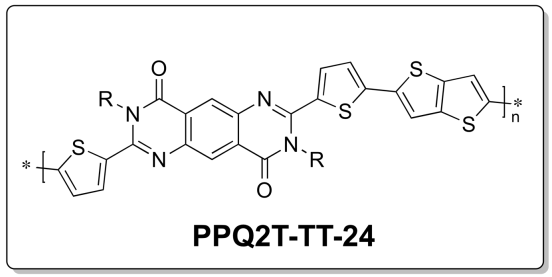


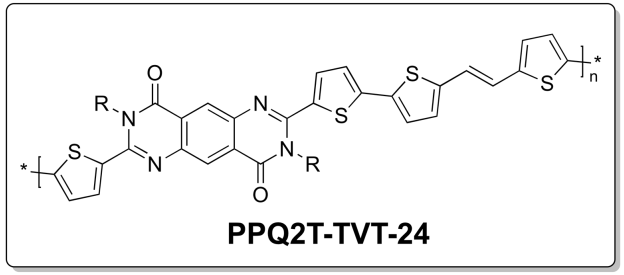
Reagents and conditions: (i) toluene, ammonium acetate, catalytic amount of acetic acid, 16 h (95%); (ii) *n*-butanol, sulfur, gentle reflux, 18 h (90%); (iii) DCM, 2-thiophenecarbonyl chloride, pyridine, 0 °C, 30 min, rt, 18 h (79%); (iv) ethanol, lithium hydroxide, 60 °C, 3 h (86%); (v) acetic anhydride, reflux, 3 h (78%); (vi) ammonium acetate, 170 ° C, 1 h, 30% sodium hydroxide, ethanol, reflux, 1 h (95%); (vii) DMF, K_2CO_3, 130 ° C, 16 h (73%); (viii) NBS, chloroform, 0 °C, rt, overnight (75%).

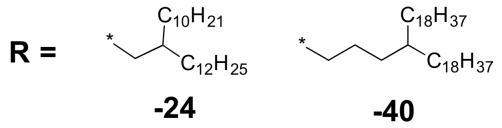
J. Quinn, E. Jin and Y. Li, *Tetrahedron Letters*, 2015, **56**, 2280–2282.







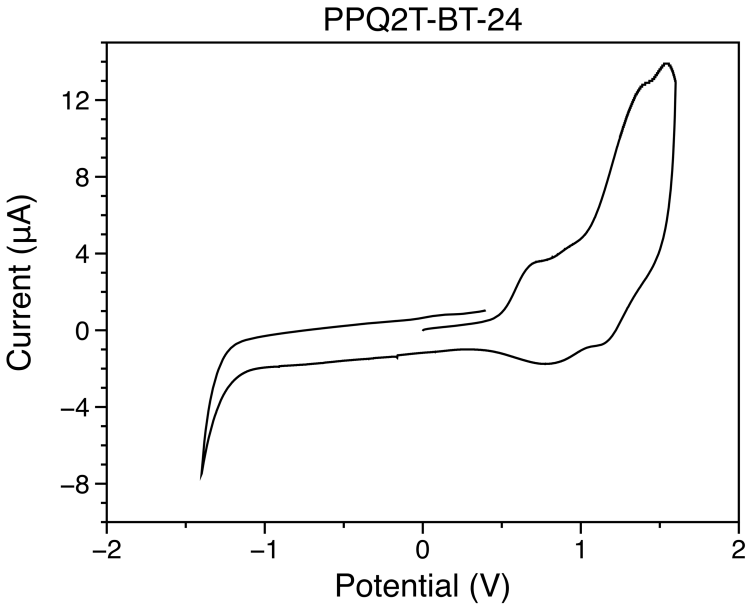


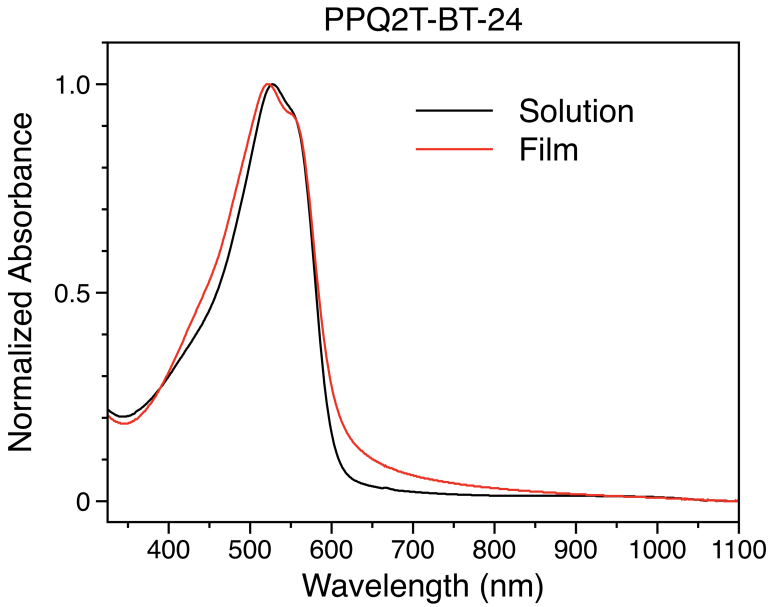


The synthetic route to **PPQ2T-BT-24**, **PPQ2T-TT-24**, and **PPQ2T-TVT-24** polymers. Reagents and conditions: (i) $Pd_2(dba)_3$/P(*o*-tolyl)$_3$/chlorobenzene/130 °C.

J. Quinn, Y. He, D. A. Khan, J. Rasmussen, H. Patel, F. Haider, W. Kapadia and Y. Li, *RSC Advances*, 2016, **6**, 78477–78485.
J. Quinn, C. Guo, B. Sun, A. Chan, Y. He, E. Jin and Y. Li, *J. Mater. Chem. C*, 2015, **3**, 11937–11944.

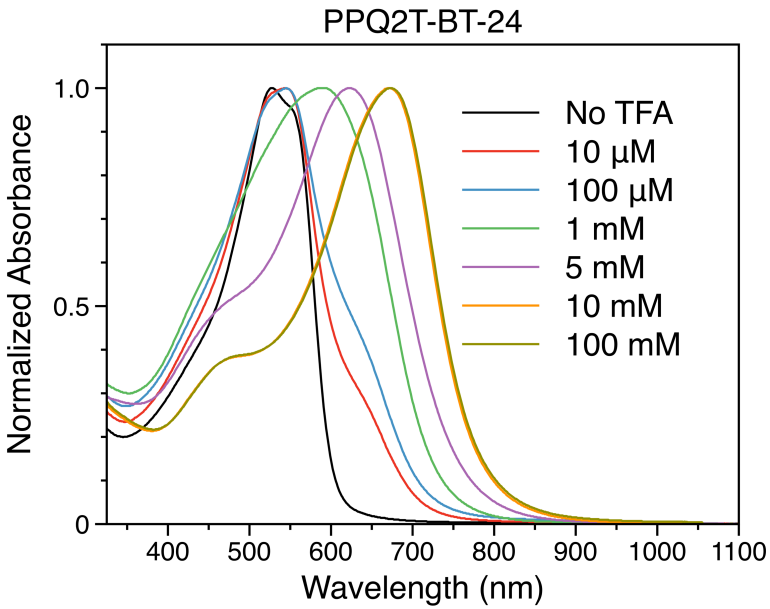
Electrochemical and Optical Properties

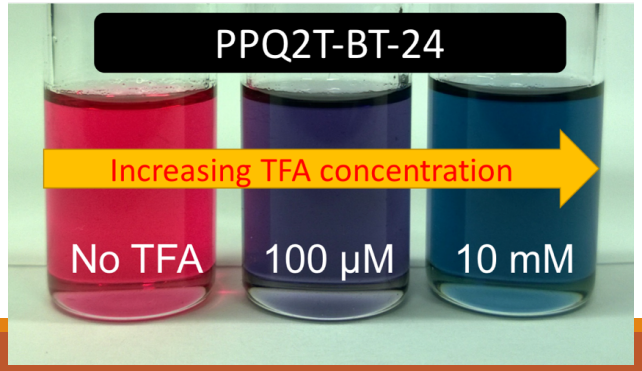


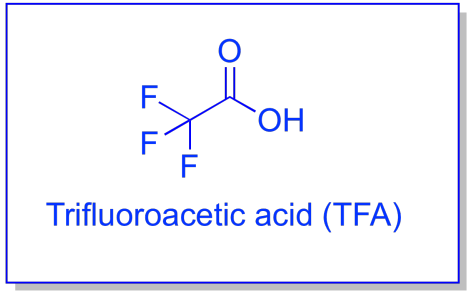


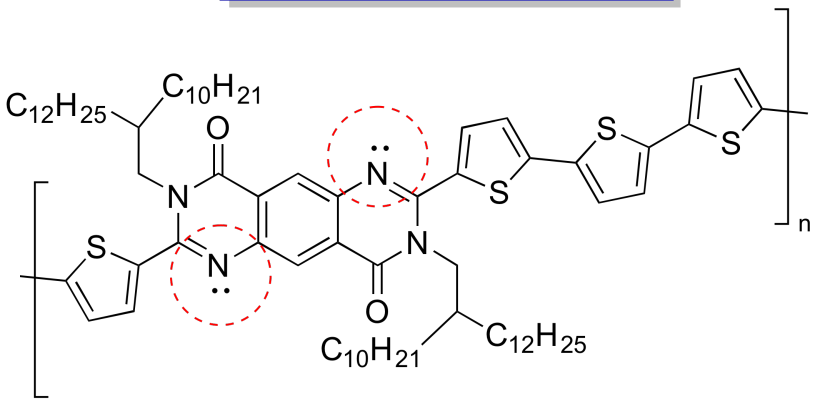
Name	LUMO (eV)	HOMO (eV)	E_g^{opt} (eV)
PPQ2T-BT-24/40	-3.27	-5.30	2.03
PPQ2T-TT-24	-3.41	-5.42	2.00
PPQ2T-TVT-24	-3.27	-5.18	1.90

Acid Study





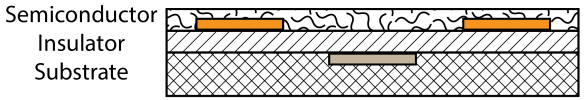


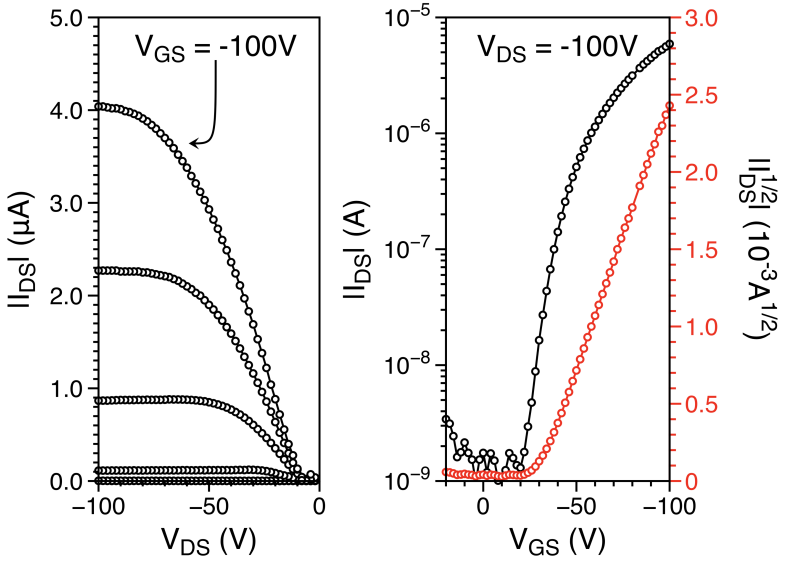


PPQ2T-BT-24

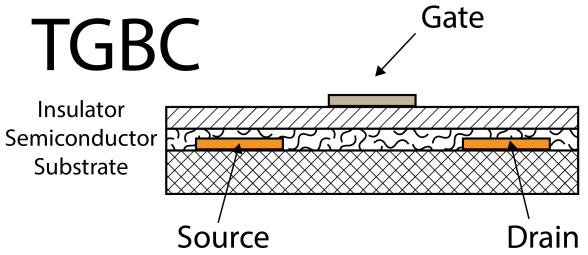
I-V Characteristics

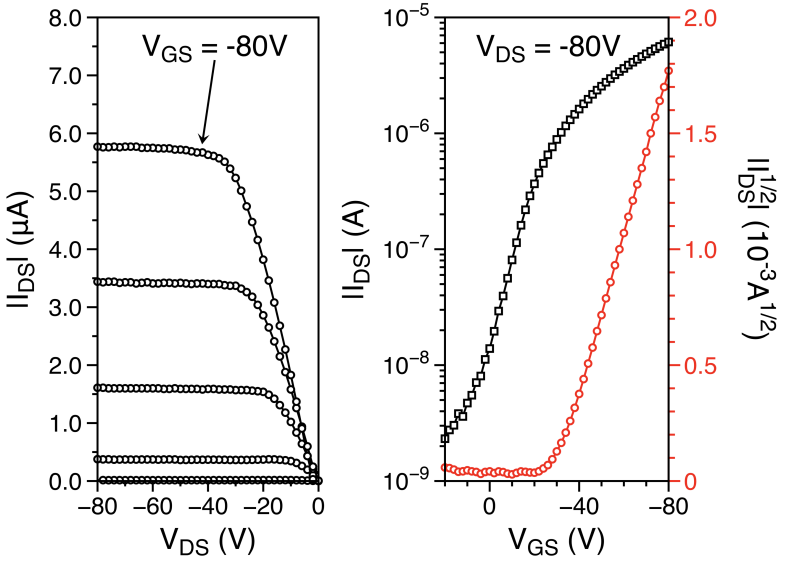
BGBC



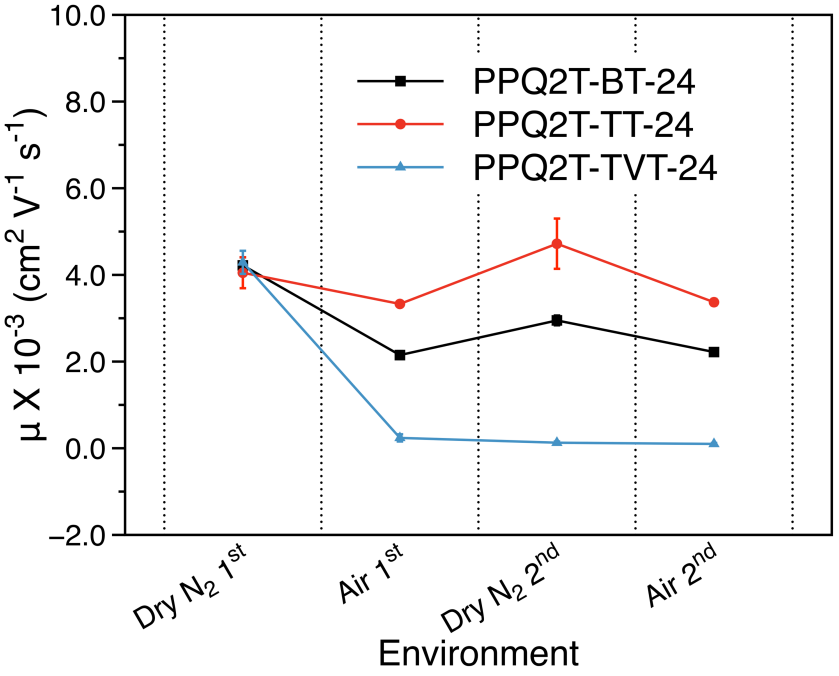


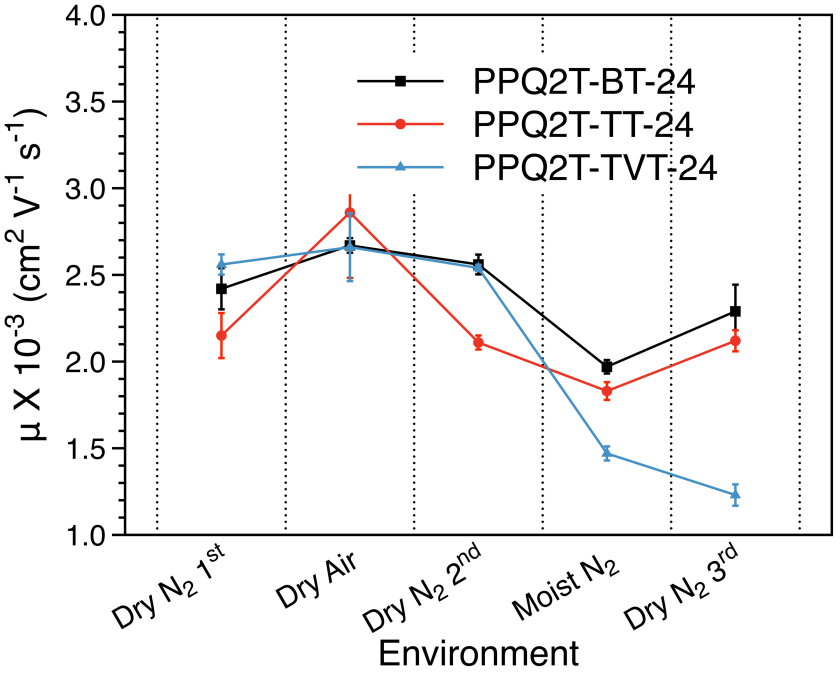
TGBC



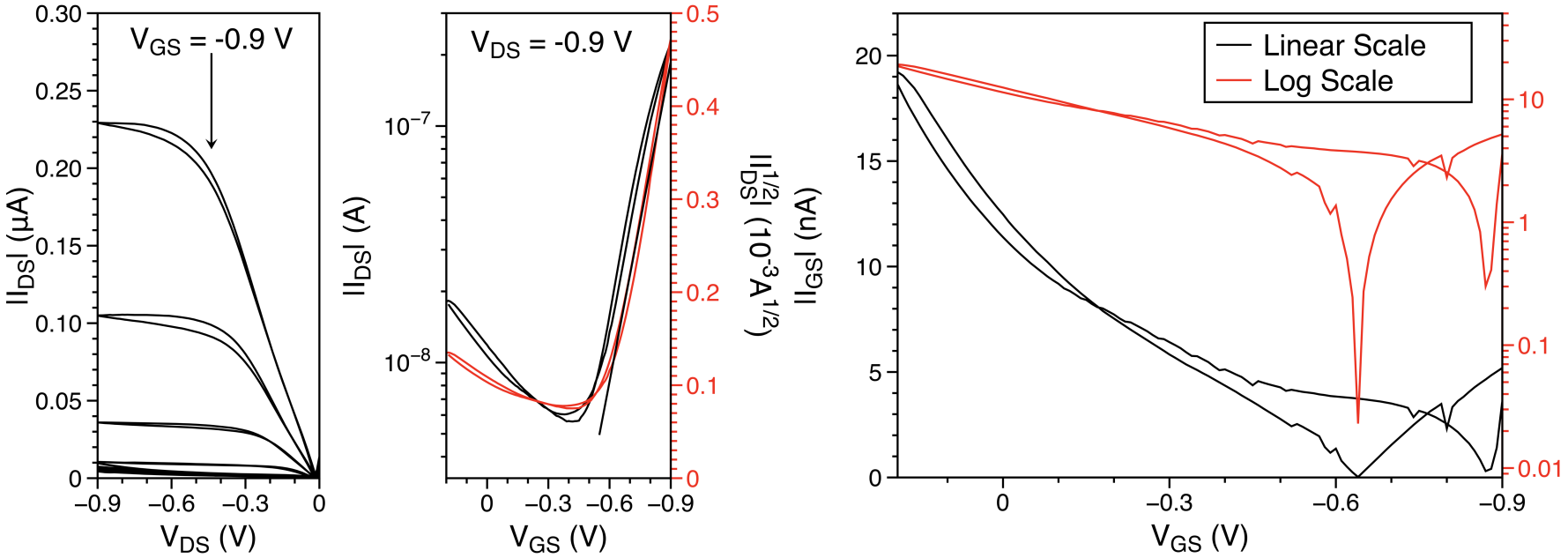


Air Stability

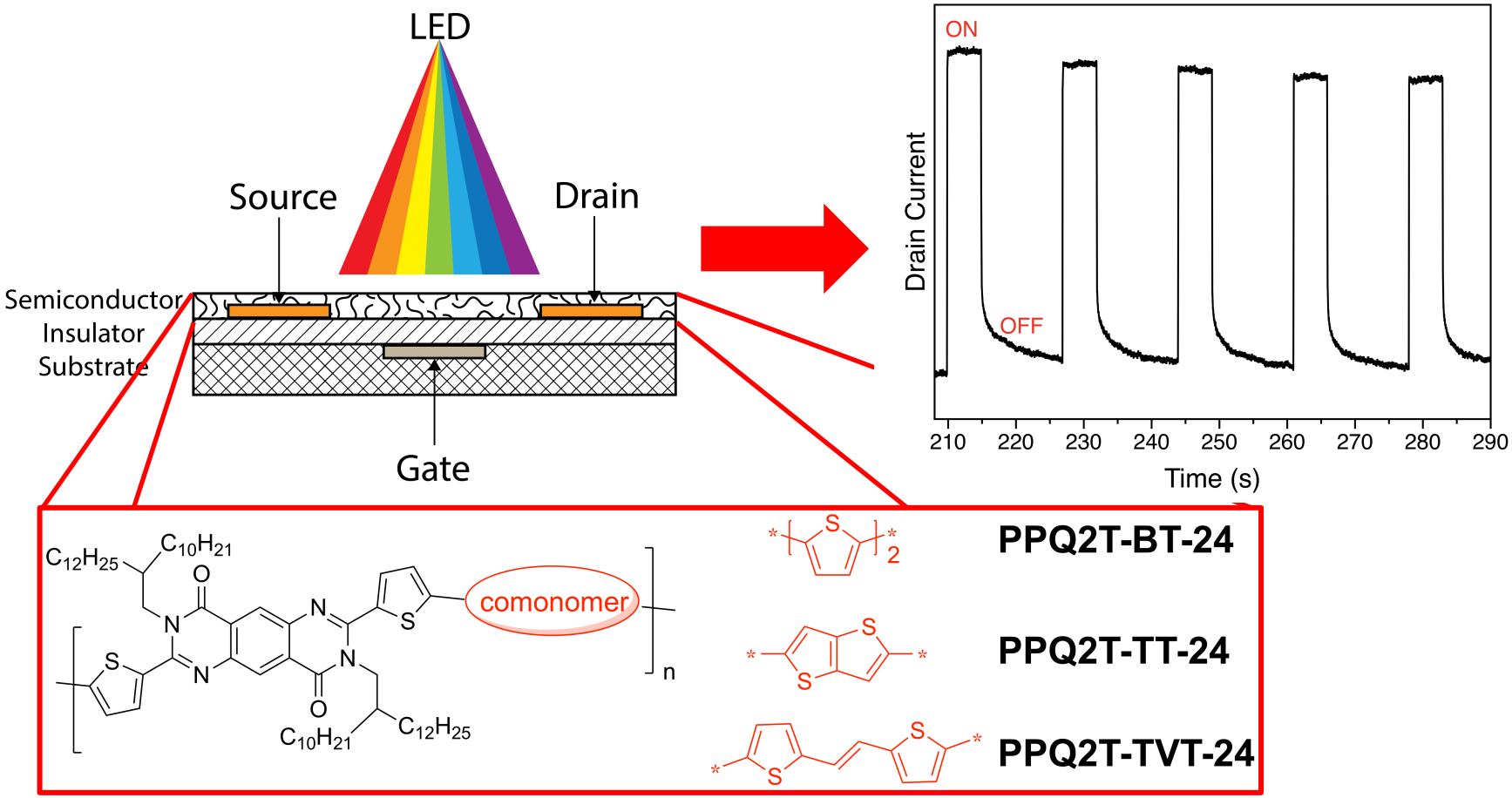




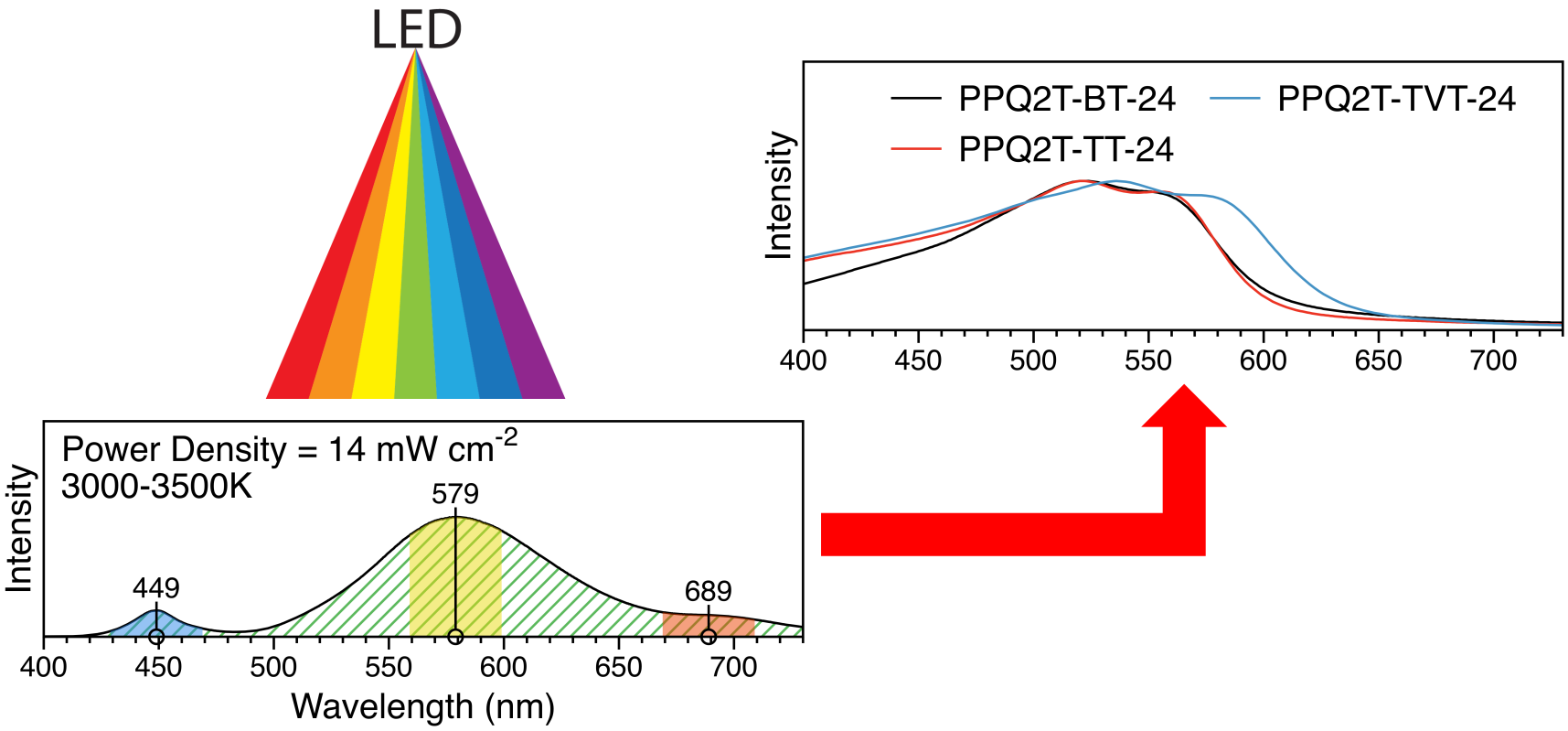
Aqueous Operation



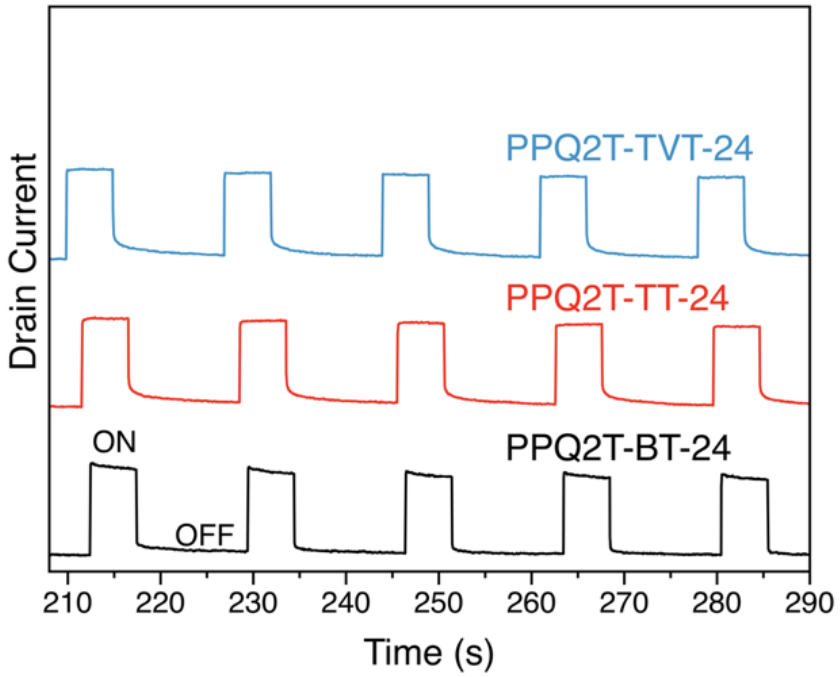
Phototransistor

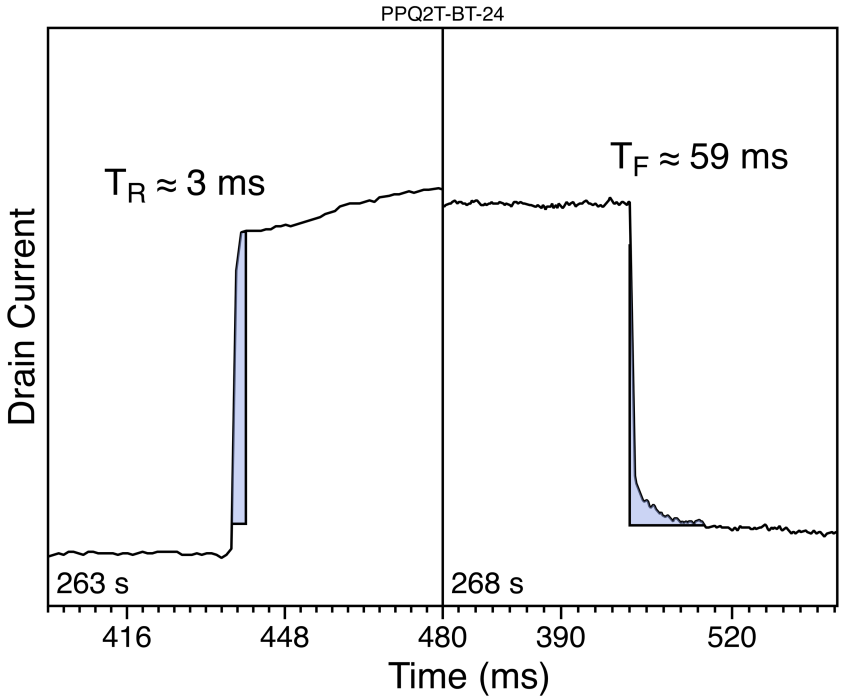


Optical Profile

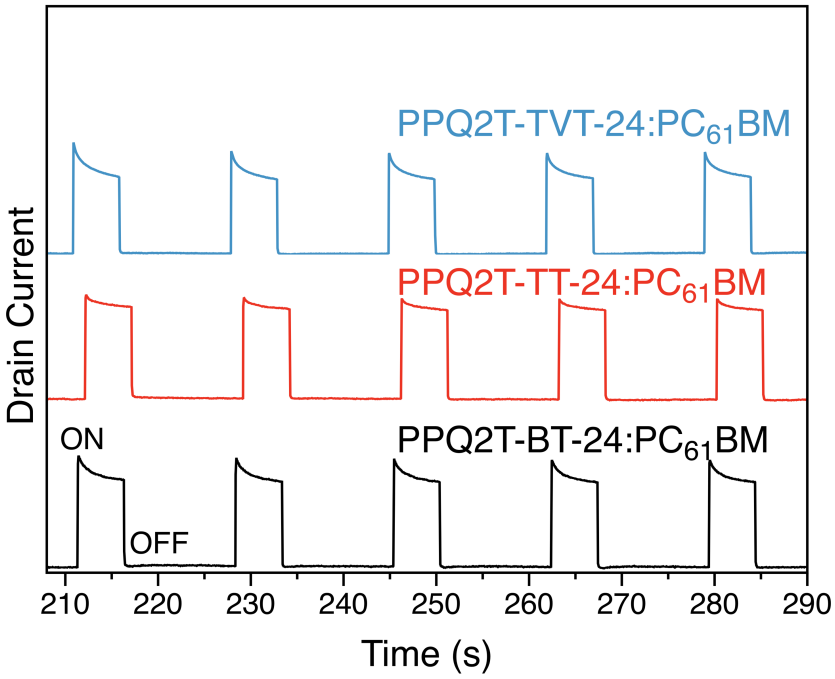


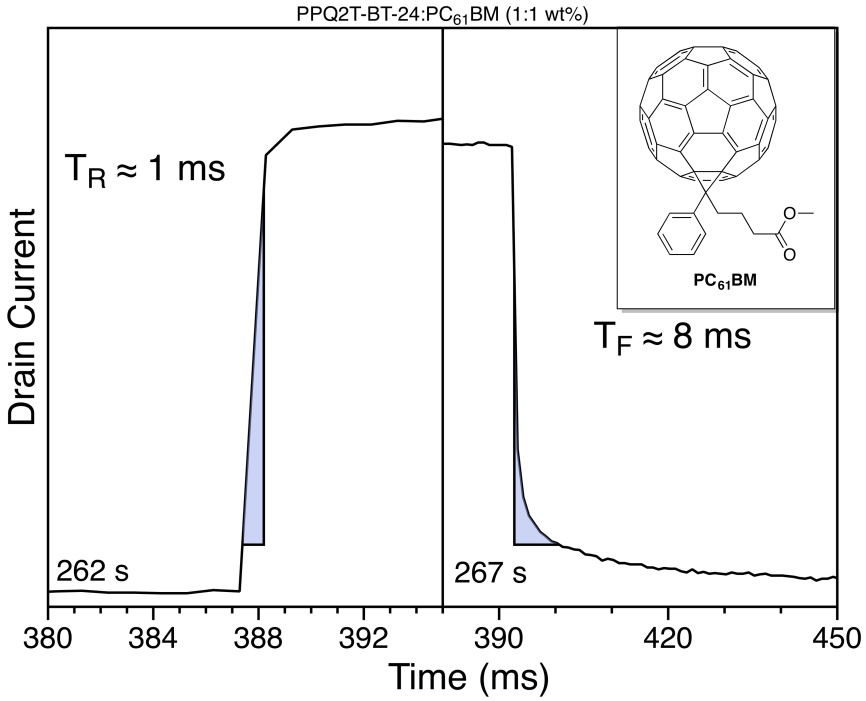
Pristine Characteristics



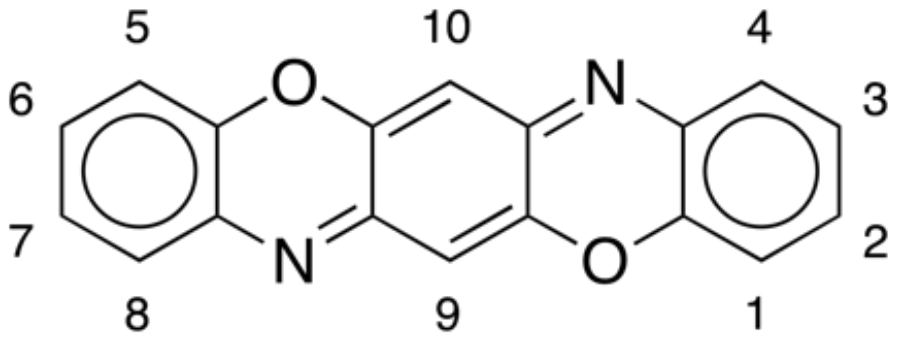


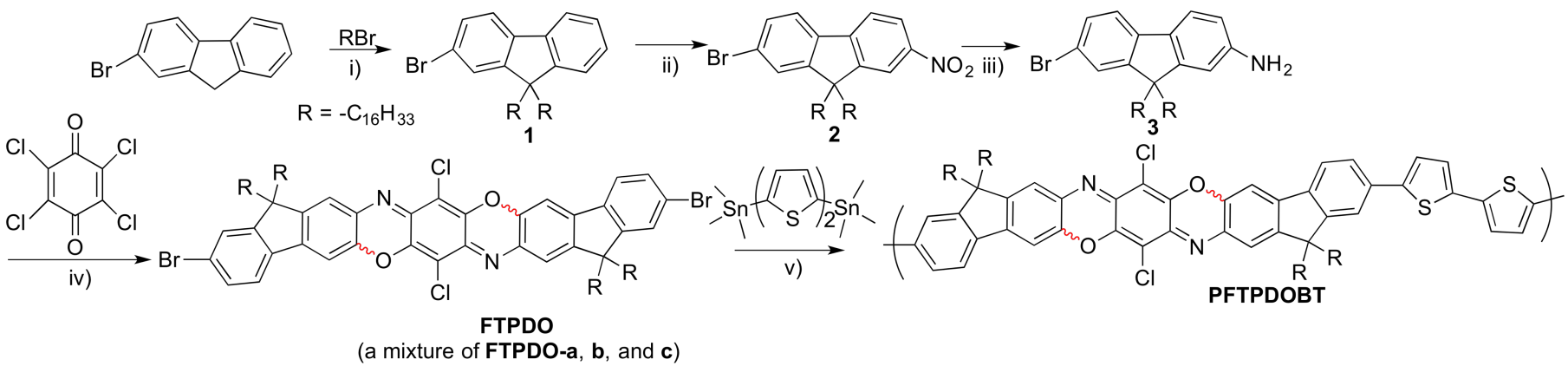
Blend Characteristics

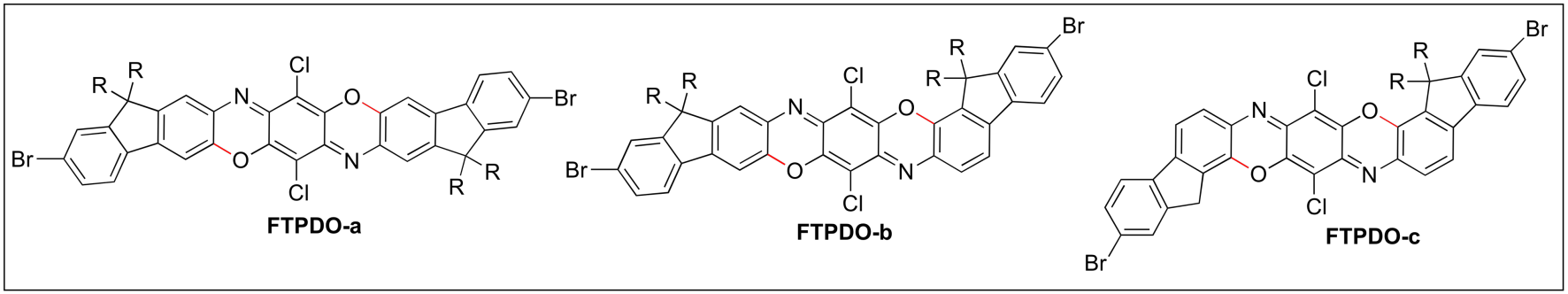




Triphenodioxazines



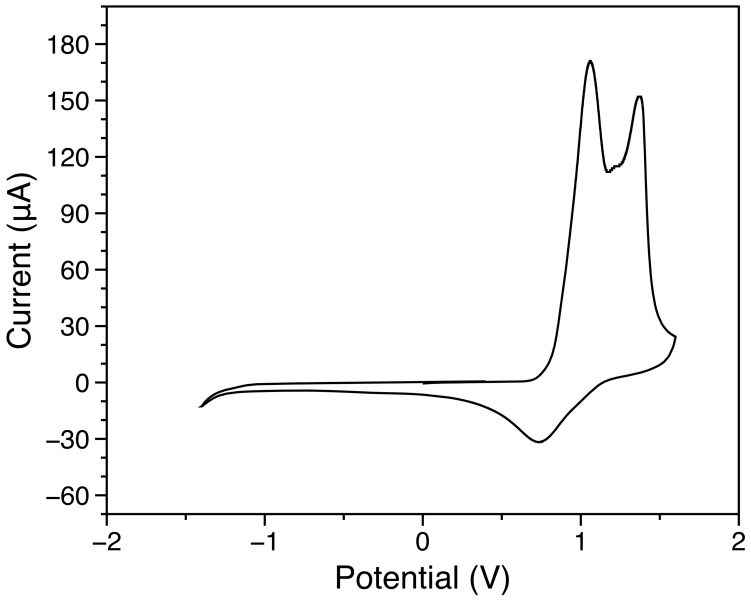


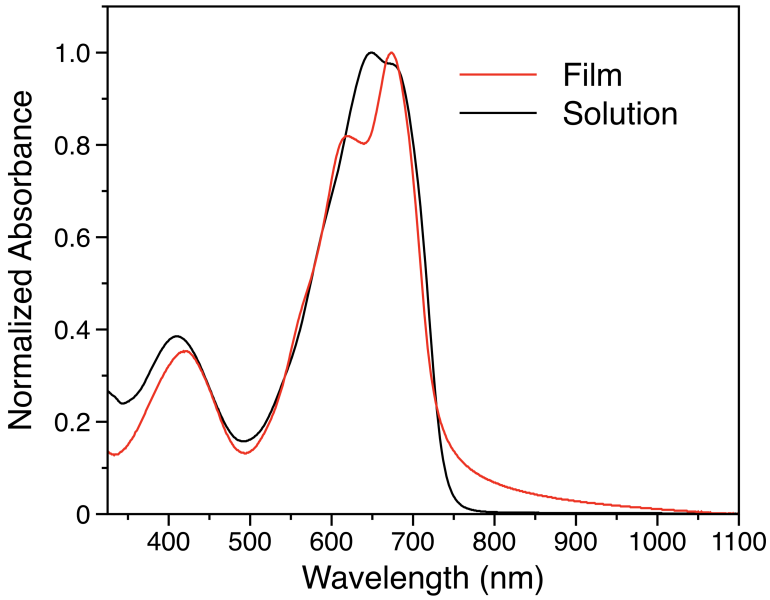


Synthetic route to **FTPDO** and its polymer **PFTPDOBT**. i) *t*-BuOK, THF, r. t., 80%; ii) 90% HNO_3, 1,2-dichloroethane, reflux, 94%; iii) $NH_2NH_2.H_2O$ (3.0 mL), $Fe(acac)_3$, ethylene glycol, 155 °C, 52%; iv) 4-toluenesulfonylchloride, nitrobenzene, 40 °C, 6%; v) $Pd_2(dba)_3$/P(*o*-tolyl)$_3$), chlorobenzene, 130 °C, 82%.

L. Guo, J. Quinn, J. Wang, C. Guo, X. Li, J. Wang and Y. Li, *Dyes and Pigments*, 2016, **132**, 329–335.

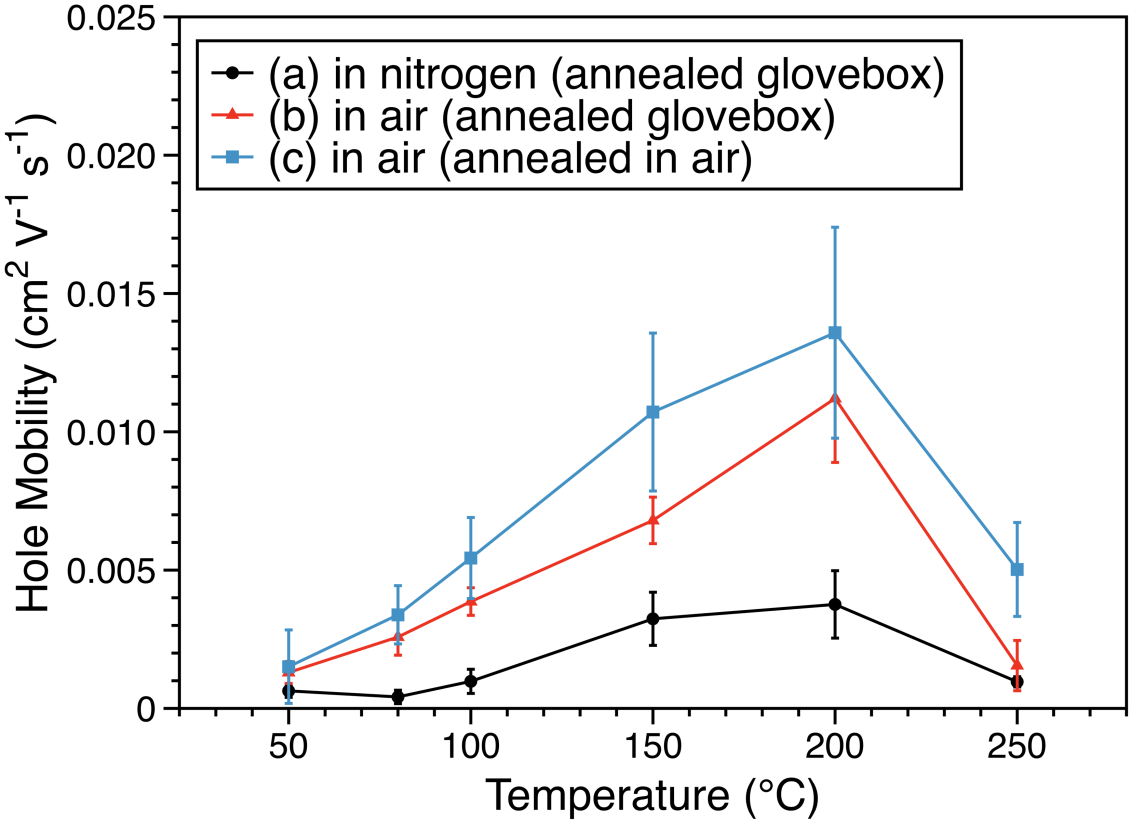
Electrochemical and Optical Properties



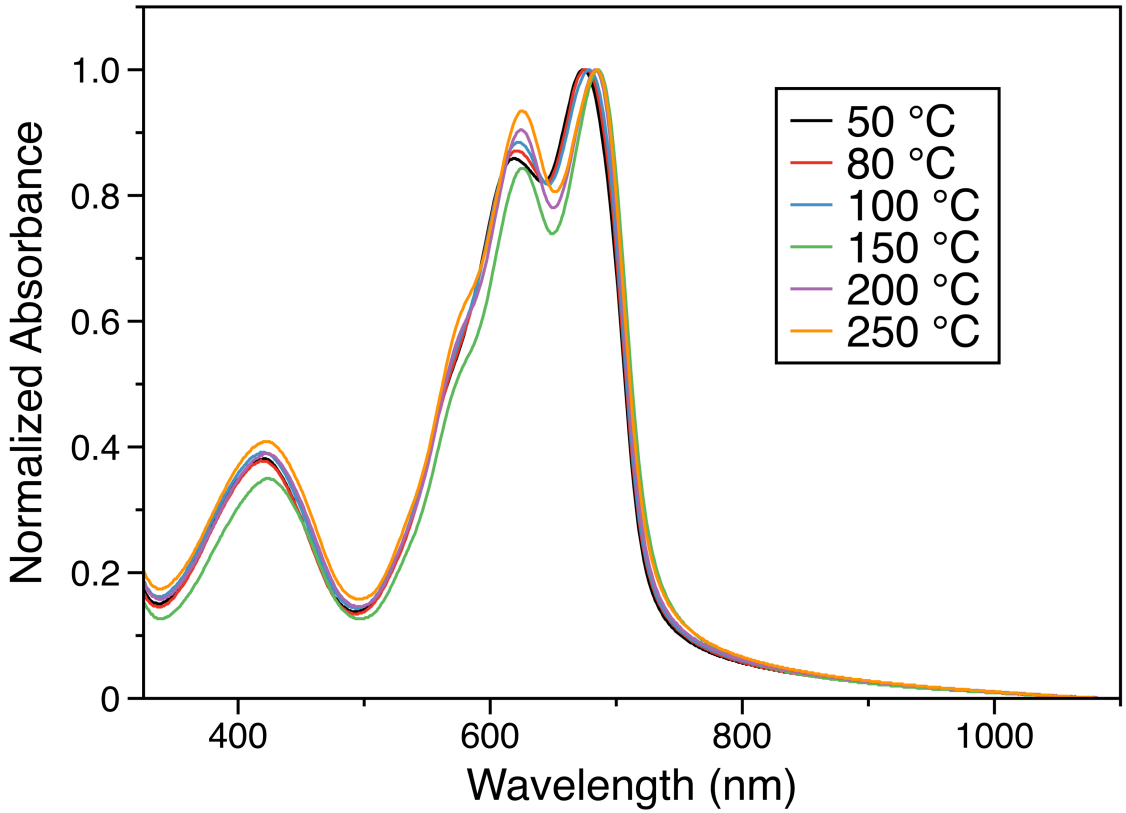


LUMO (eV)	HOMO (eV)	E_g^{opt} (eV)
-3.95	-5.61	1.66

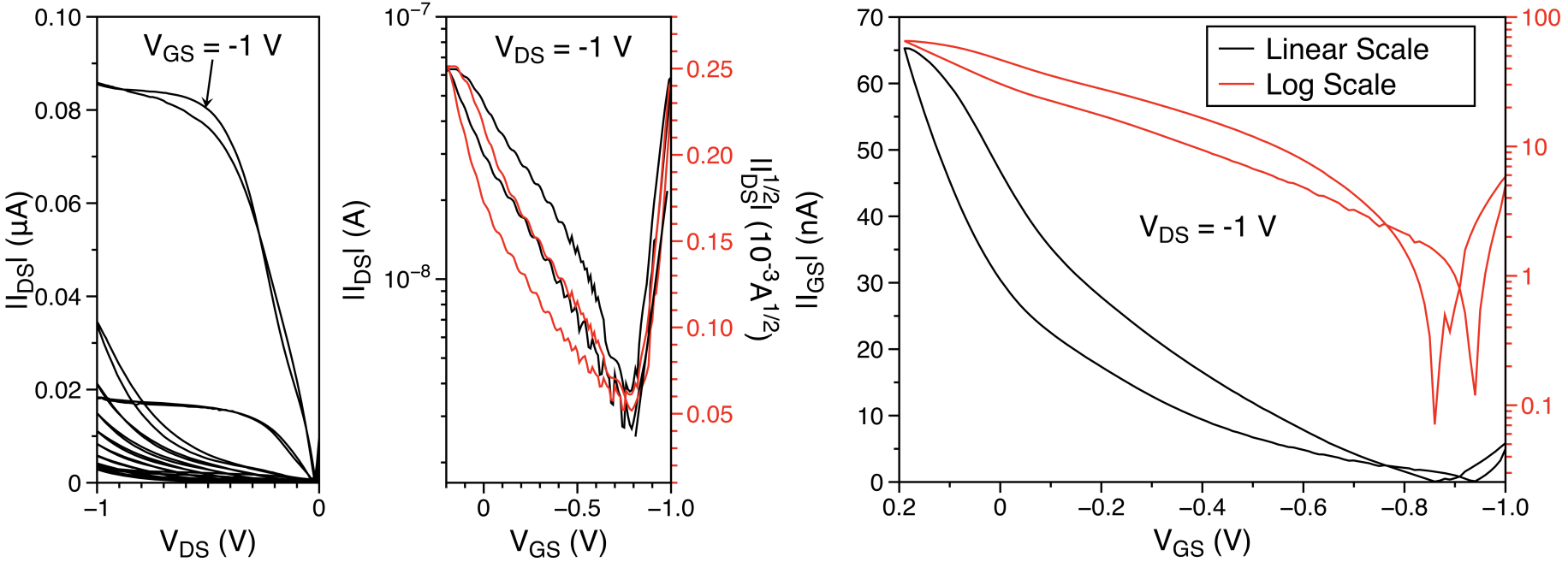
Air Stability



Air Stability



Aqueous Operation



Modest Transistor Performance

Demonstrates modest hole mobility in TGBC

Air stable operation in BGBC

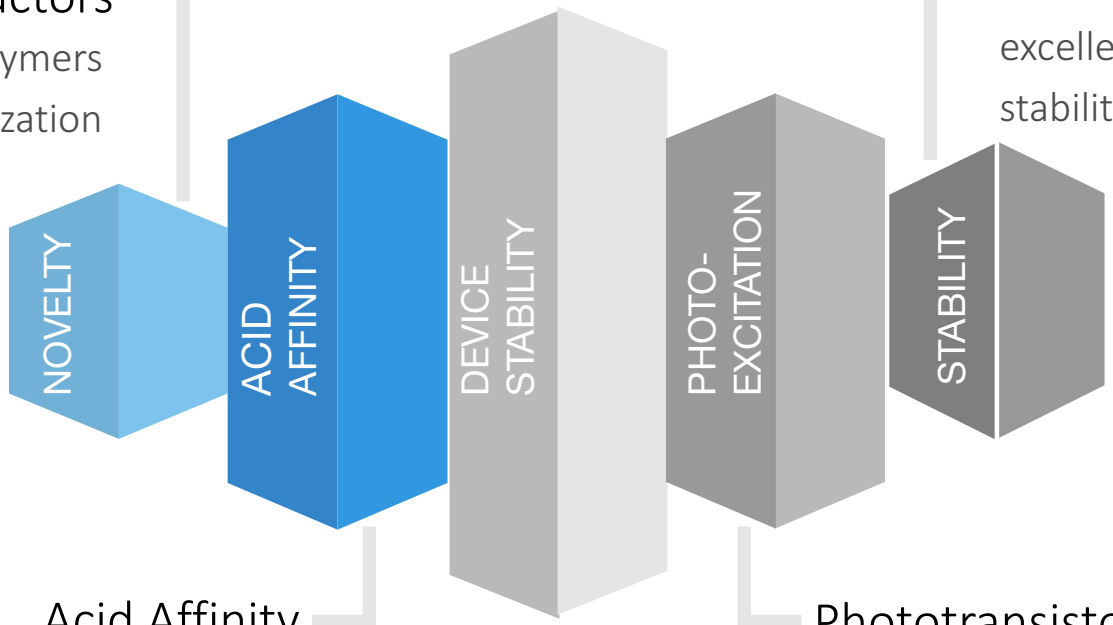
Stable aqueous operation

Novel Semiconductors

Series of PQ polymers and full characterization

Thermal Stability

PFTPDOBT should excellent thermal stability in air



Acid Affinity

Strong interaction with organic and Lewis acids

Phototransistor

Marked response times in OPTs

Thanks

Supervisor: Dr Yuning Li

Group: Yinghui He, Jenner Ngai, Dr. Mylène LeBorgne, Dr. Chang Guo, Dr. Bin Sun, Dr. Yun-Feng Deng, and Dr. Wei Hong

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