Fabrication of organic near-infrared photodetectors by coating techniques

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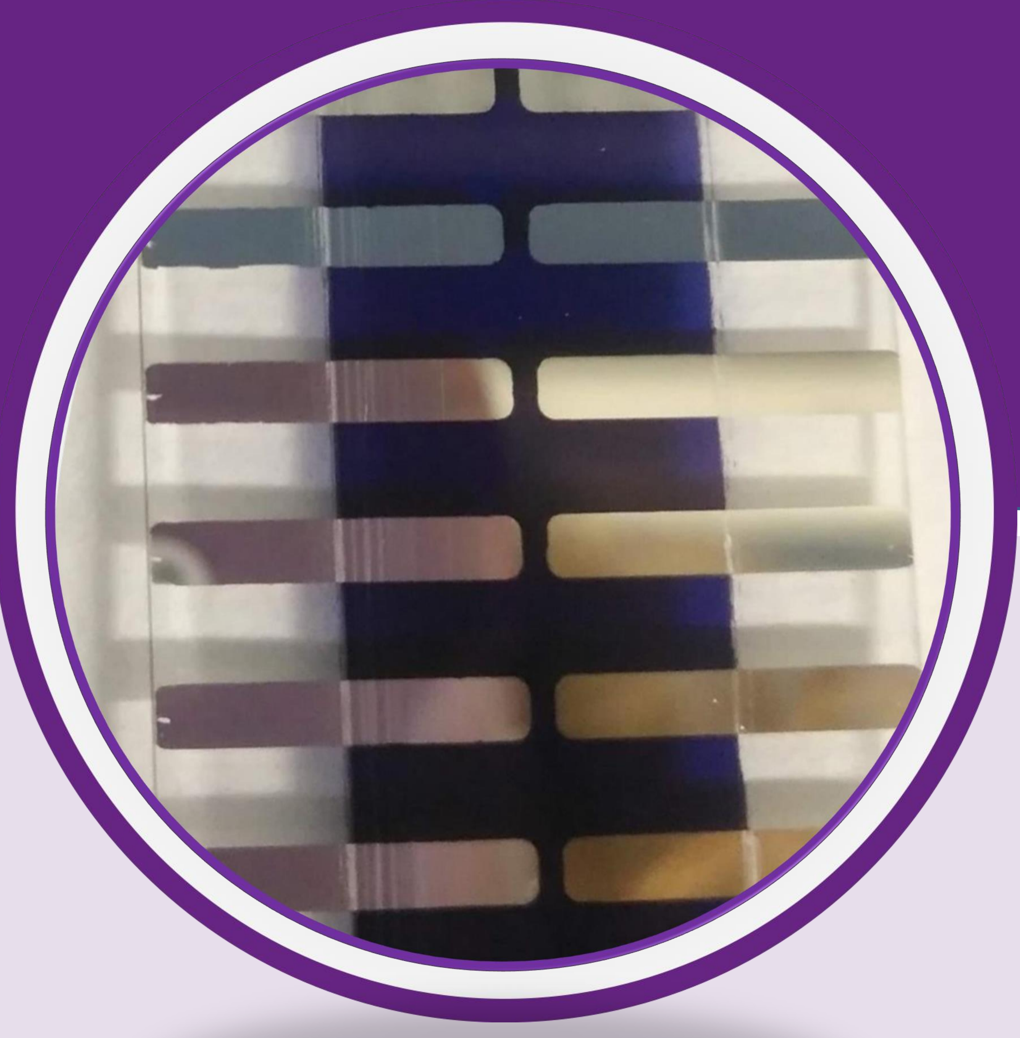
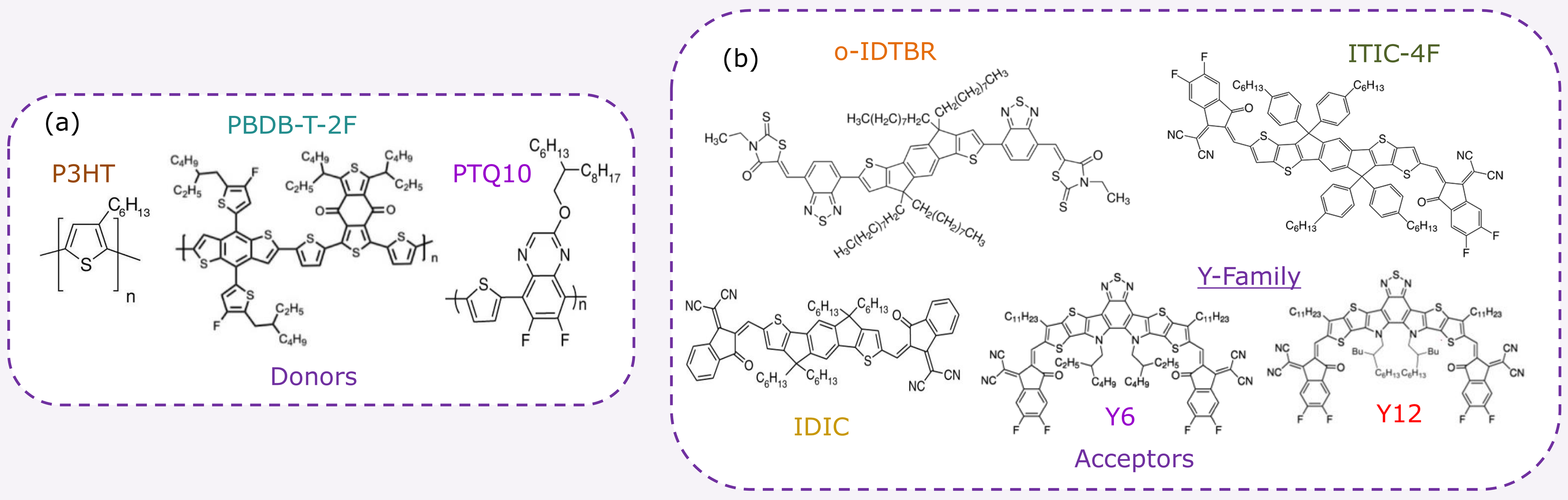
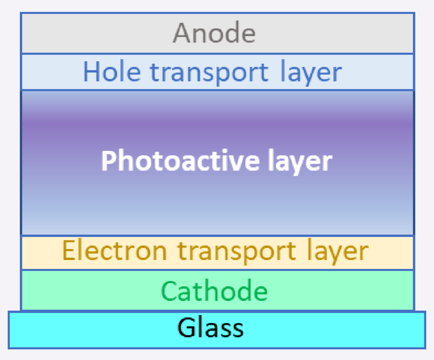


Organic based **near-infrared photodetectors** offer the potential advantages of being flexible, light-weight and low cost. These types of photodetectors can be made by **solution processing** techniques, such as a **blade coating** (at lab scale) and slot-die coating (when upscaling).
The **photophysical and optoelectronic properties** of organic photodetectors can be broadly **adjusted** by means of **organic chemistry**. The molecular design strategy is based on donor-acceptor (D:A) bulk heterojunction concept. This concept combine **polymers** and the currently emerging **small molecular** acceptors, namely **non-fullerene acceptors (NFA)**. This work focus on studying of **performance and stability after 5 months** of photodetectors based on a **polymeric donor (P3HT or PBDBT-2F or PTQ10)** blended with one **NFA (o-IDTBR or ITIC-4F or IDIC or Y-family)**. In particular, we use high throughput screening methods to select the best material systems in terms of EQE and dark current.

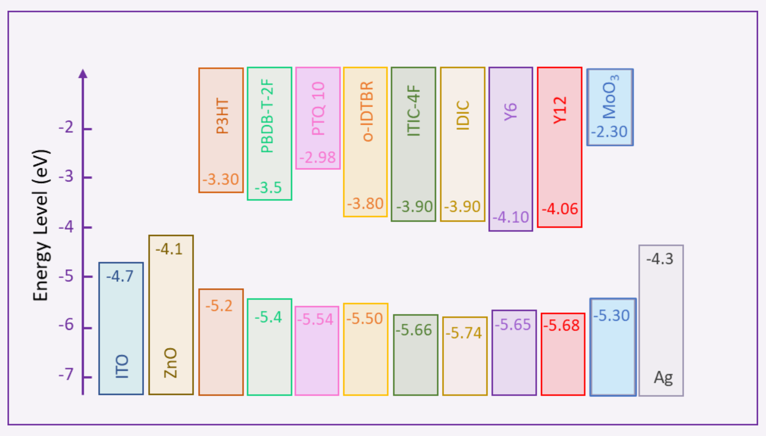
❖ Chemical structures of photoactive materials



Scheme 1. (a)Chemical structure of polymer donors P3HT, PBDB-T-2F and PTQ10; (b) Chemical structures of Non-fullerene acceptors o-IDTBR, ITIC-4F, IDIC & Y-family (Y6, Y12)



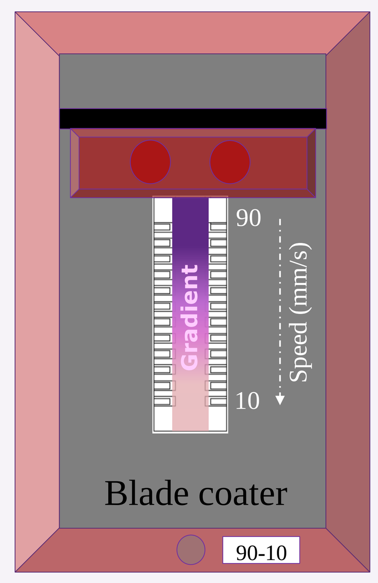
Scheme 2. Schematic structure of organic photodetector in inverted geometry



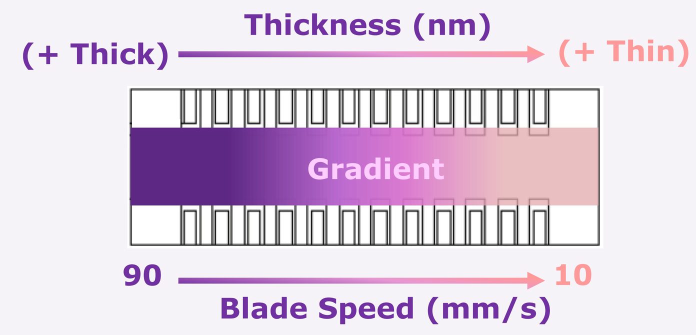
Scheme 3. Energy-level diagram showing the HOMO and LUMO energies of each material

❖ Organic photodetectors by Blade coating

Blade coater equipment



Scheme 4. Pixeled substrate with gradient of photoactive material by blade coating technique



Scheme 5. Pixeled substrate with a thickness gradient of photoactive material

Table 1. Conditions of Blade coating for each material

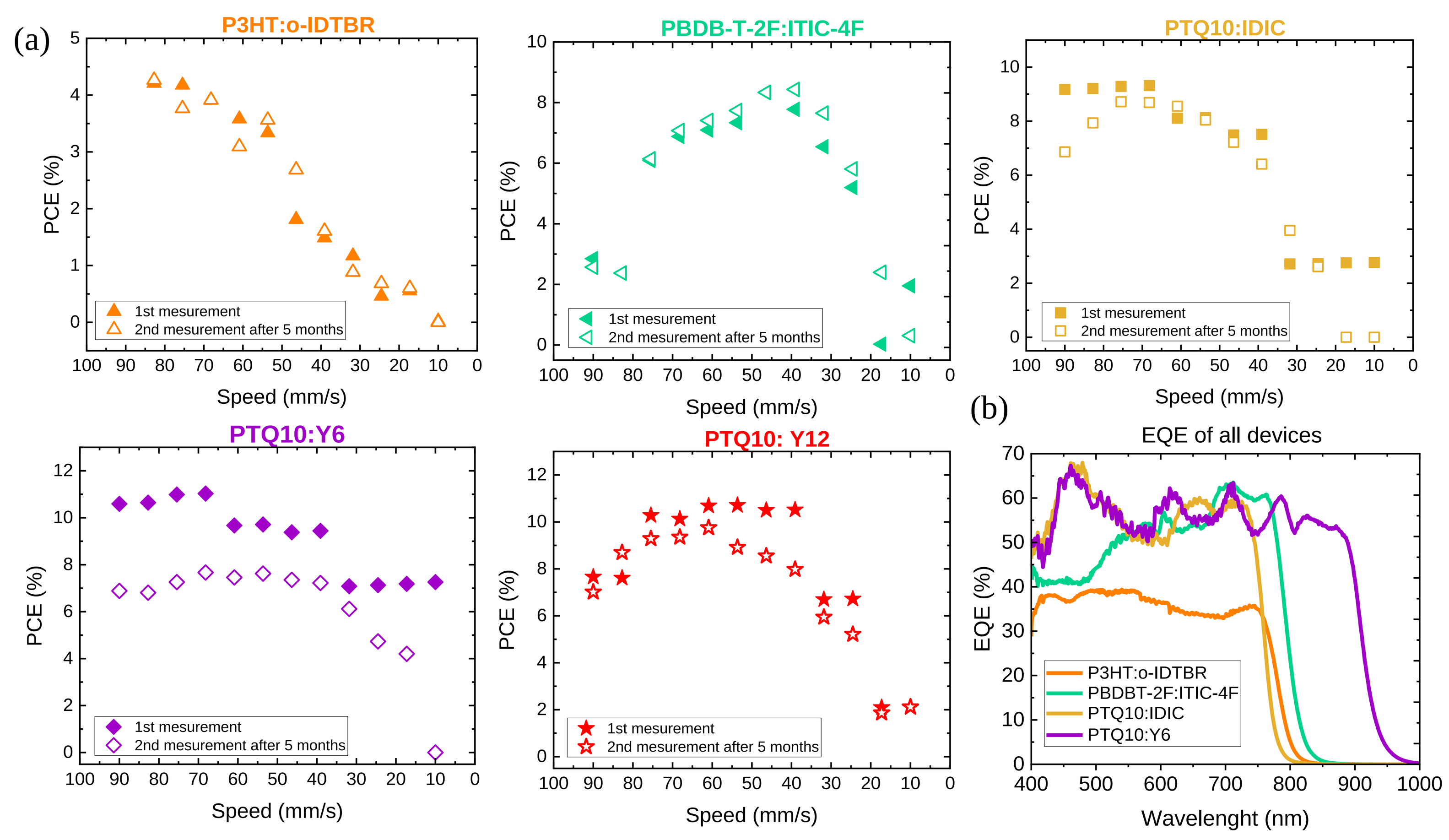
Materials	Concentration	Solvent	Blade speed (mm/s)	W (µm)	Hot plate (ºC)	Anneling (ºC, min)
ZnO (ETL)	2.5 wt %	IPA	5	150,1000	40	100,10
Donor:Acceptor (PAL)	20 mg/ml (1:1.5)	CB	90-10	200,1000	88	100,10

IPA: Isopropanol CB: Chlorobenzene

Results

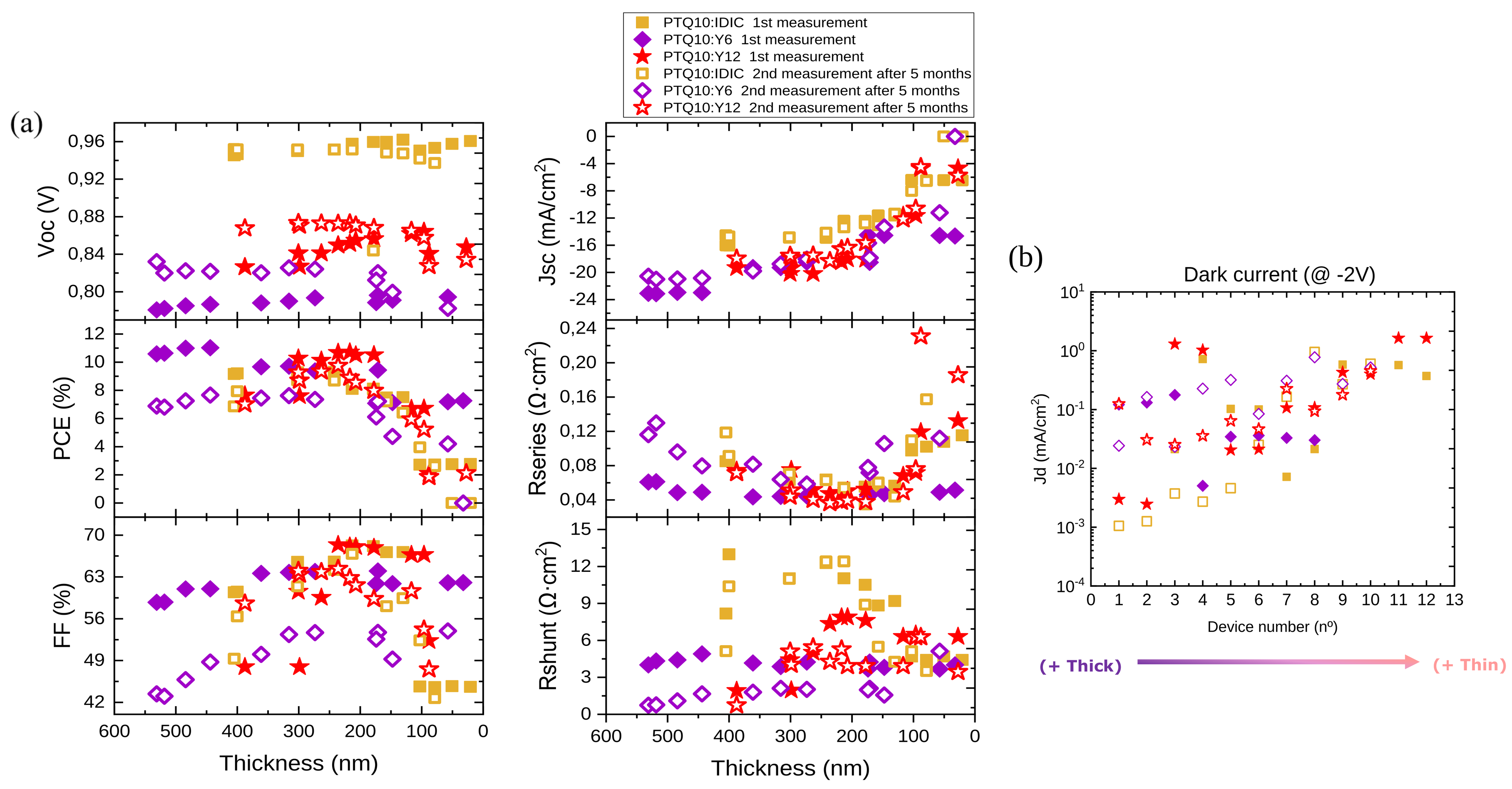
❖ Screening of photoactive materials in devices

- **Studying of performance and stability after 5 months**



Scheme 6. (a) Efficiency vs blade speed for each system under study (b) EQE measurements of P3HT:o-IDTBR, PBDBT-2F:ITIC-4F, PTQ10:IDIC and PTQ10:Y6

- **Thickness dependence of device performance in PTQ10: IDIC & Y-Family**



Scheme 7. (a) Thickness dependence of device performance on the PTQ10:IDIC, Y6 & Y12. (b) Dark current @ -2V for each system.

Conclusions

1. **High % PCE** values were obtained with **fast Blade speed** ⟷ **Large thickness of active layer in all systems**
2. The **highest PCE** were found for **PTQ10 and different NFA**
3. After 5 months stored in nitrogen, the devices were only degraded mildly
4. EQE values above 50% were measured for PBDB-T-2F:ITIC-4F, PTQ10:IDIC, and PTQ10:Y6 systems
5. The **lowest dark current** obtained was **10-3 mA/cm2 (@ -2V) in PTQ10:IDIC system**

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