

Semi-conducteurs Isotropes et Stables pour Cellules Solaires Organiques

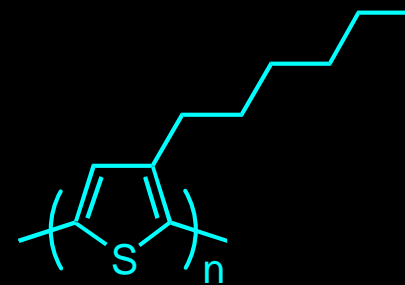
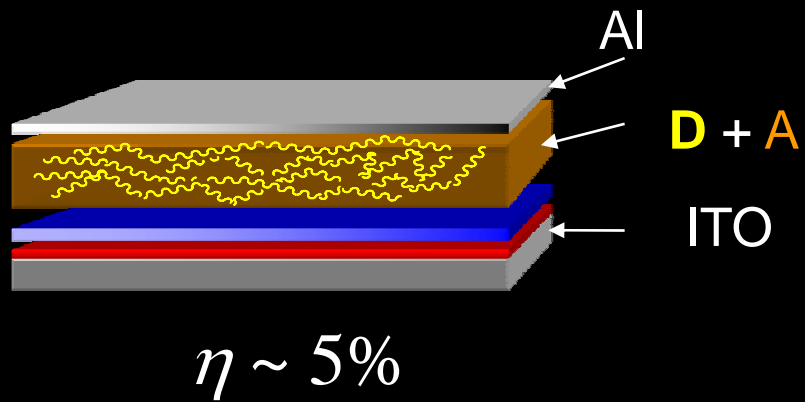
SISCO

Hétérojonctions Volumiques Moléculaires

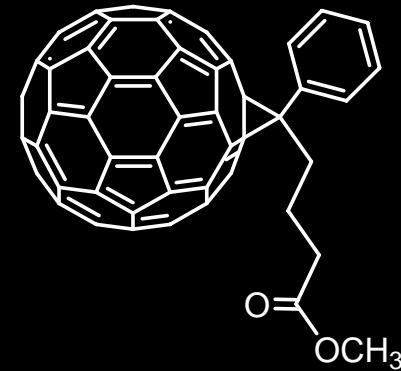
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CNRS, CIMA, Université d'Angers

Partenaire : Raymond Ziessel, Université Louis Pasteur, Strasbourg,

Polymeric Bulk Heterojunctions

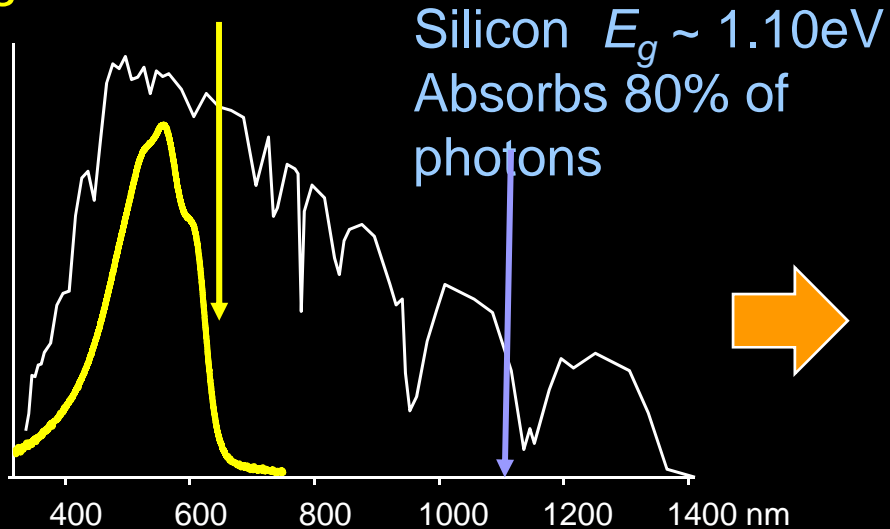


Donor
P3HT



Acceptor
PCBM

P3HT, $E_g \sim 2.00$ eV
Absorbs 30% of
photons



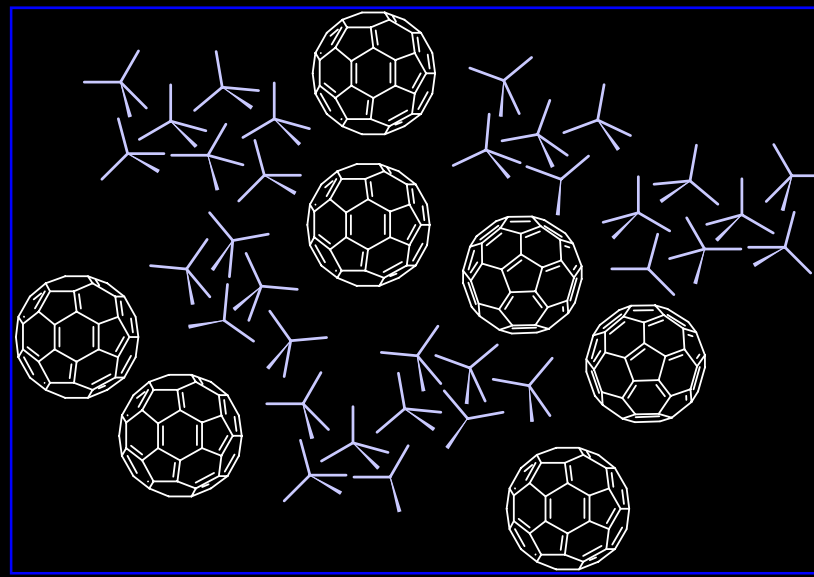
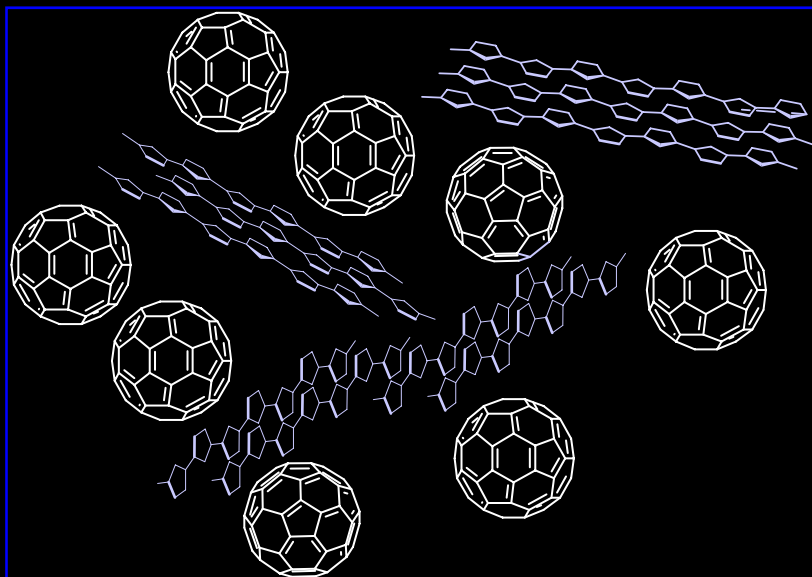
Silicon $E_g \sim 1.10$ eV
Absorbs 80% of
photons

Donneurs à gap réduit
et spectre d'absorption élargi

Polymeric donors : control of

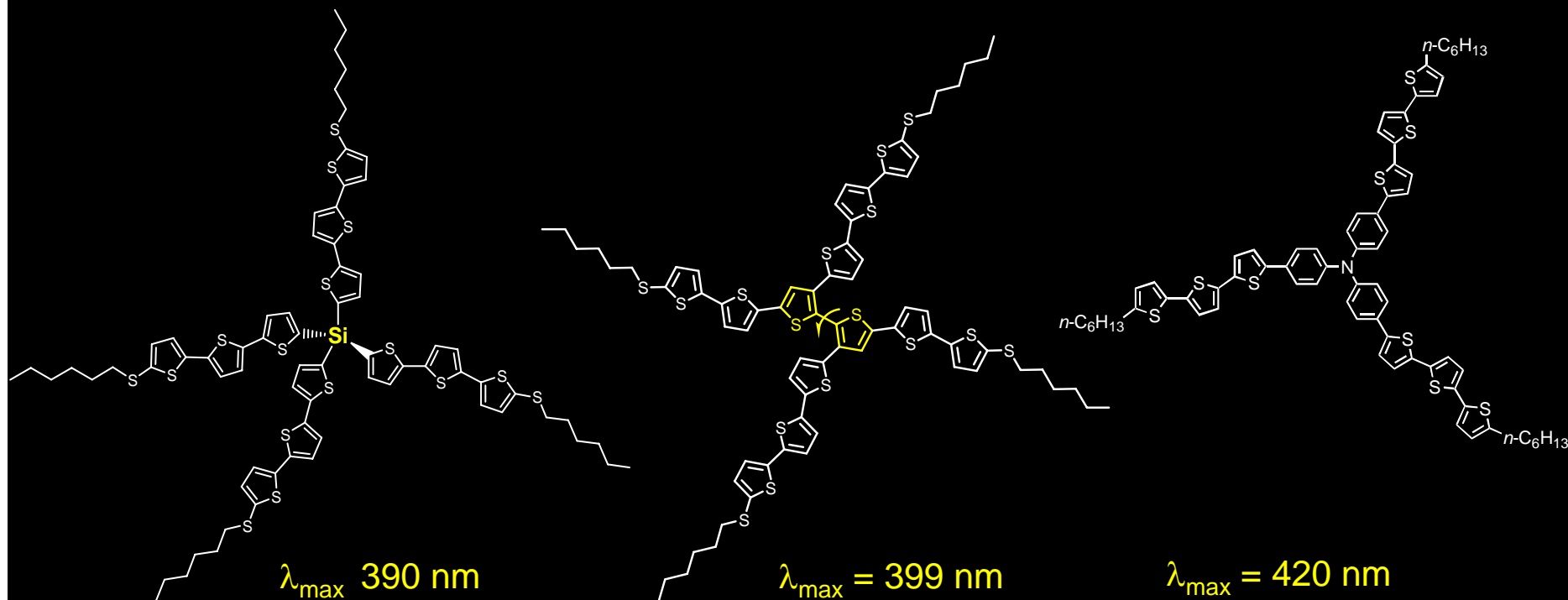
- Regioregularity
- Molecular weight
- Polydispersity
- Purity
- Crystallinity
- Reproducibility

Molecular Bulk Heterojunction Solar cells



- Monodisperse unequivocal chemical structure
- Synthesis, purification, reproducibility
- Structure-properties relationships

BHJ Solar Cells Based on Molecular Donors

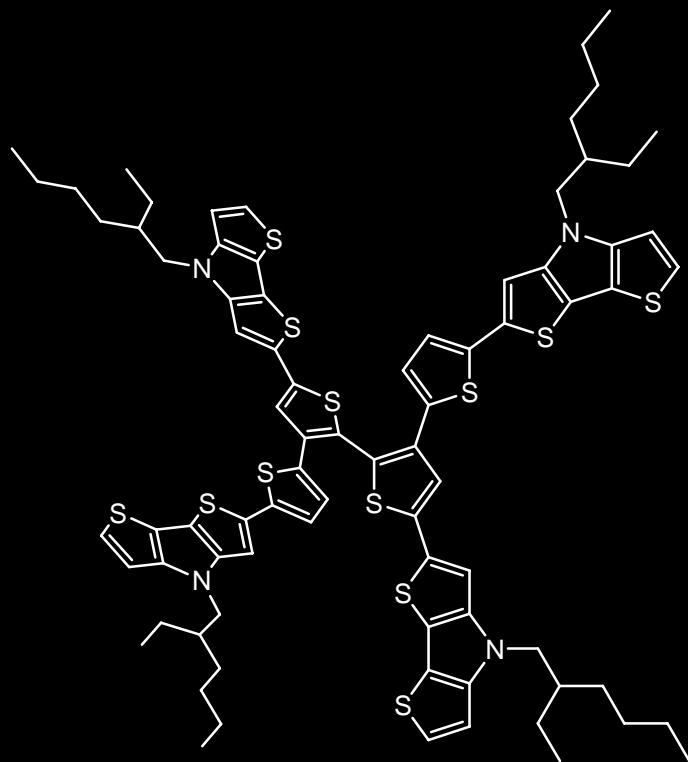


$V_{oc} = 0.85$ V
 $J_{sc} = 1.13$ mA cm⁻²
 $\eta = 0.30$ %

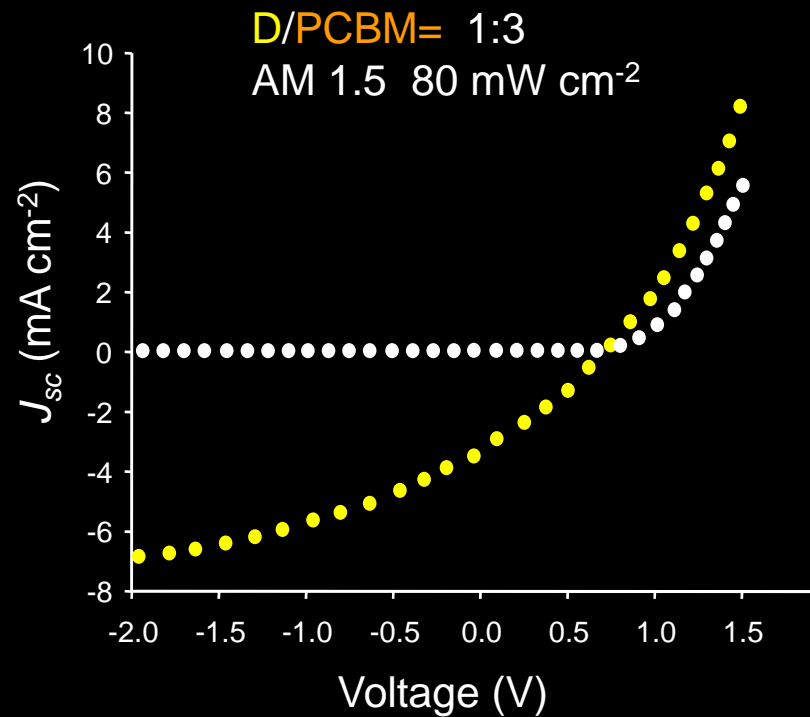
$V_{oc} = 0.51$ V
 $J_{sc} = 1.33$ mA cm⁻²
 $\eta = 0.20$ %

$J_{sc} = 1.70$ mA cm⁻²
 $V_{oc} = 0.67$ V
 $\eta = 0.33$ %

3D molecular Donors with Improved Transport Properties



$$\lambda_{max} = 400 \text{ nm}$$

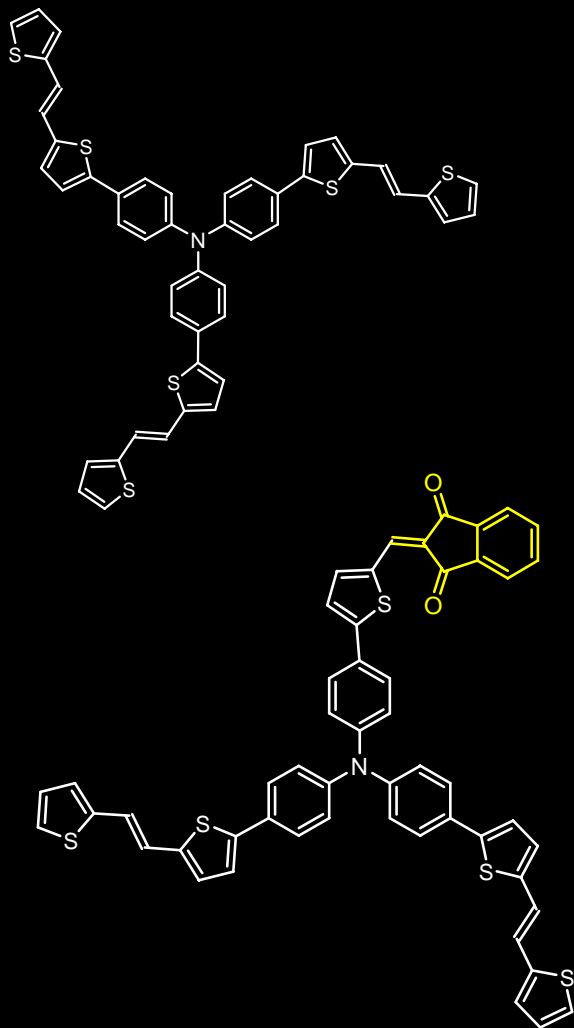


$$V_{oc} = 0.74 \text{ V}$$

$$J_{sc} = 3.04 \text{ mA cm}^{-2}$$

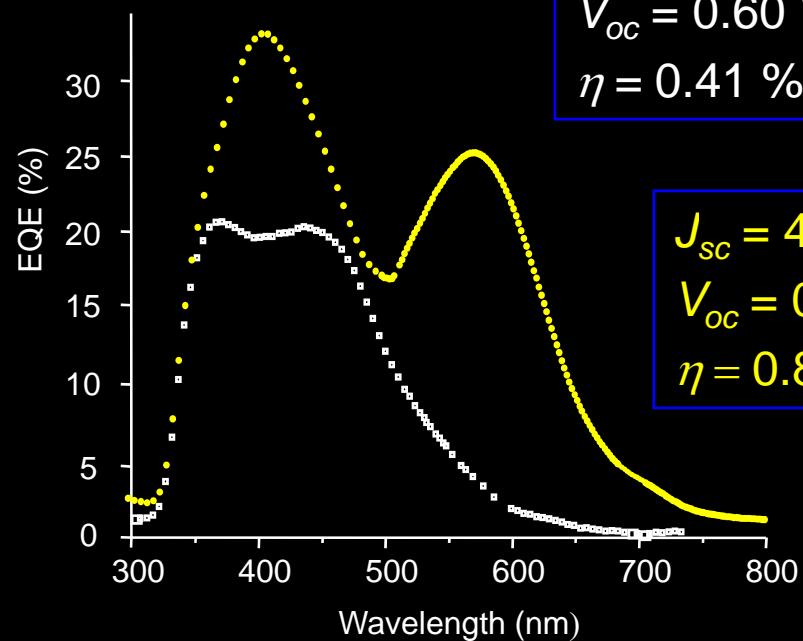
$$\eta = 0.80\%$$

3D Donors with Internal Charge Transfer



BHJ, donor/PCBM 1:1

$J_{sc} = 2.43 \text{ mA cm}^{-2}$
 $V_{oc} = 0.60 \text{ V}$
 $\eta = 0.41 \%$

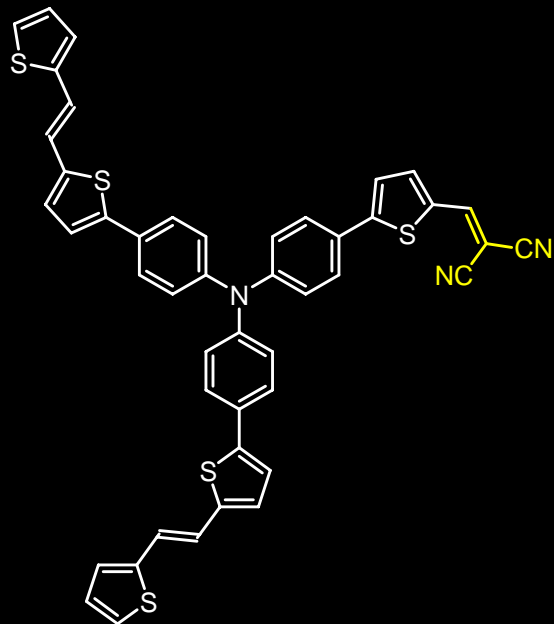


$J_{sc} = 4.10 \text{ mA cm}^{-2}$
 $V_{oc} = 0.66 \text{ V}$
 $\eta = 0.81 \%$

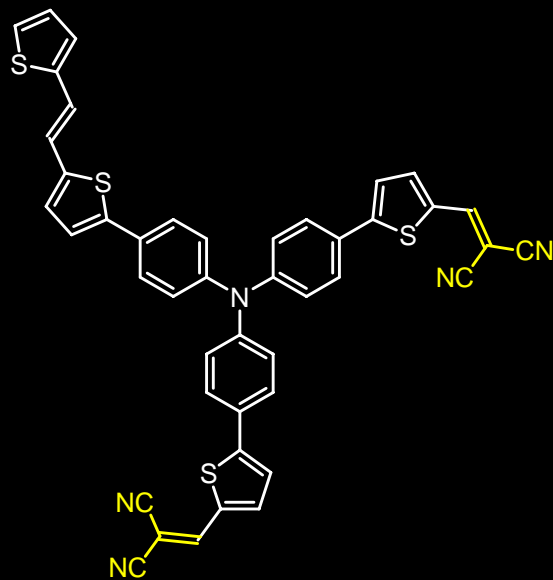
J. Am. Chem. Soc. 2006, 128, 3459

120 citations au 1/11/2009

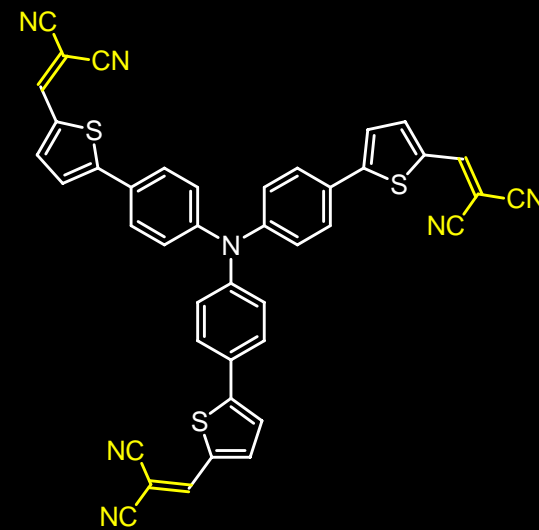
Effect of ICT on Voltage and Efficiency



$$J_{sc} = 2.0 \text{ mA cm}^{-2}$$
$$V_{oc} = 0.70 \text{ V}$$
$$\eta = 0.50 \%$$

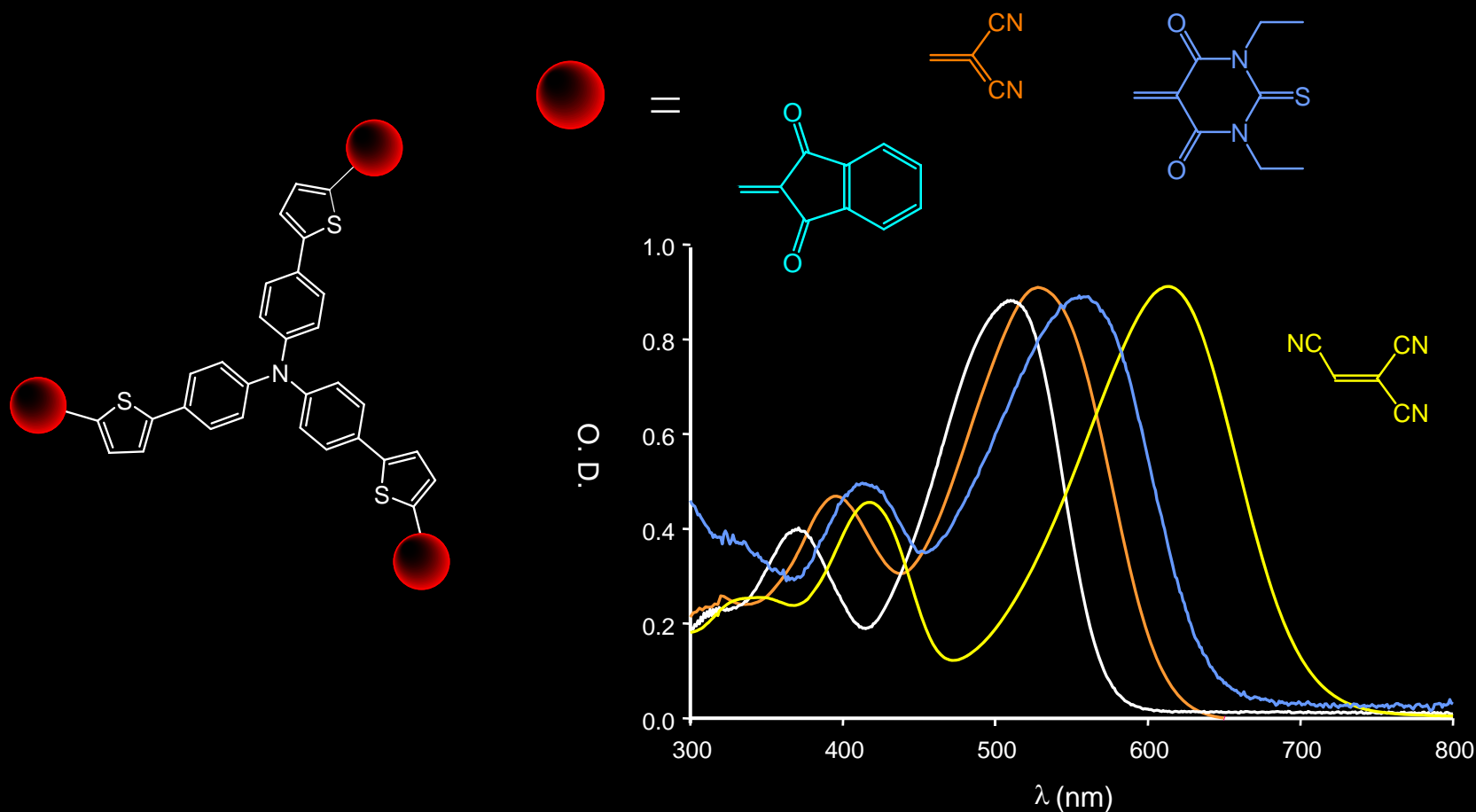


$$J_{sc} = 3.7 \text{ mA cm}^{-2}$$
$$V_{oc} = 0.90 \text{ V}$$
$$\eta = 1.20 \%$$



$$J_{sc} = 4.7 \text{ mA cm}^{-2}$$
$$V_{oc} = 1.15 \text{ V}$$
$$\eta = 1.85 \%$$

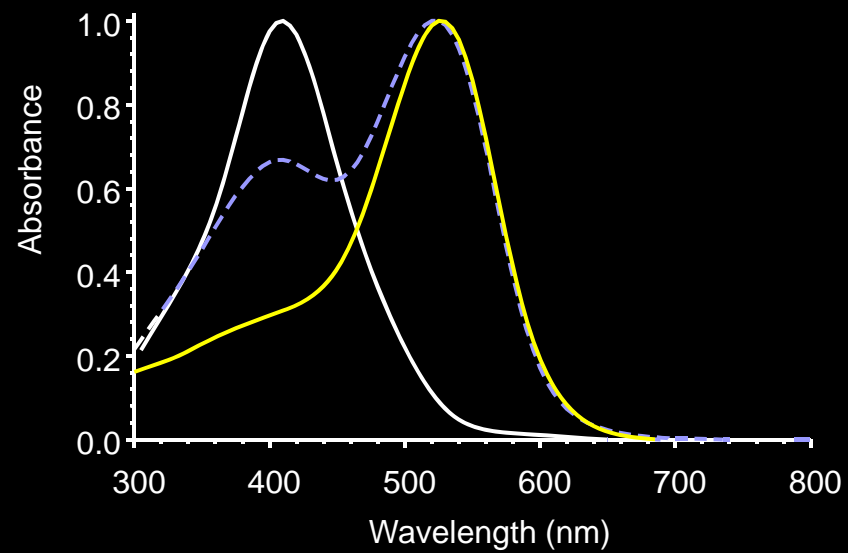
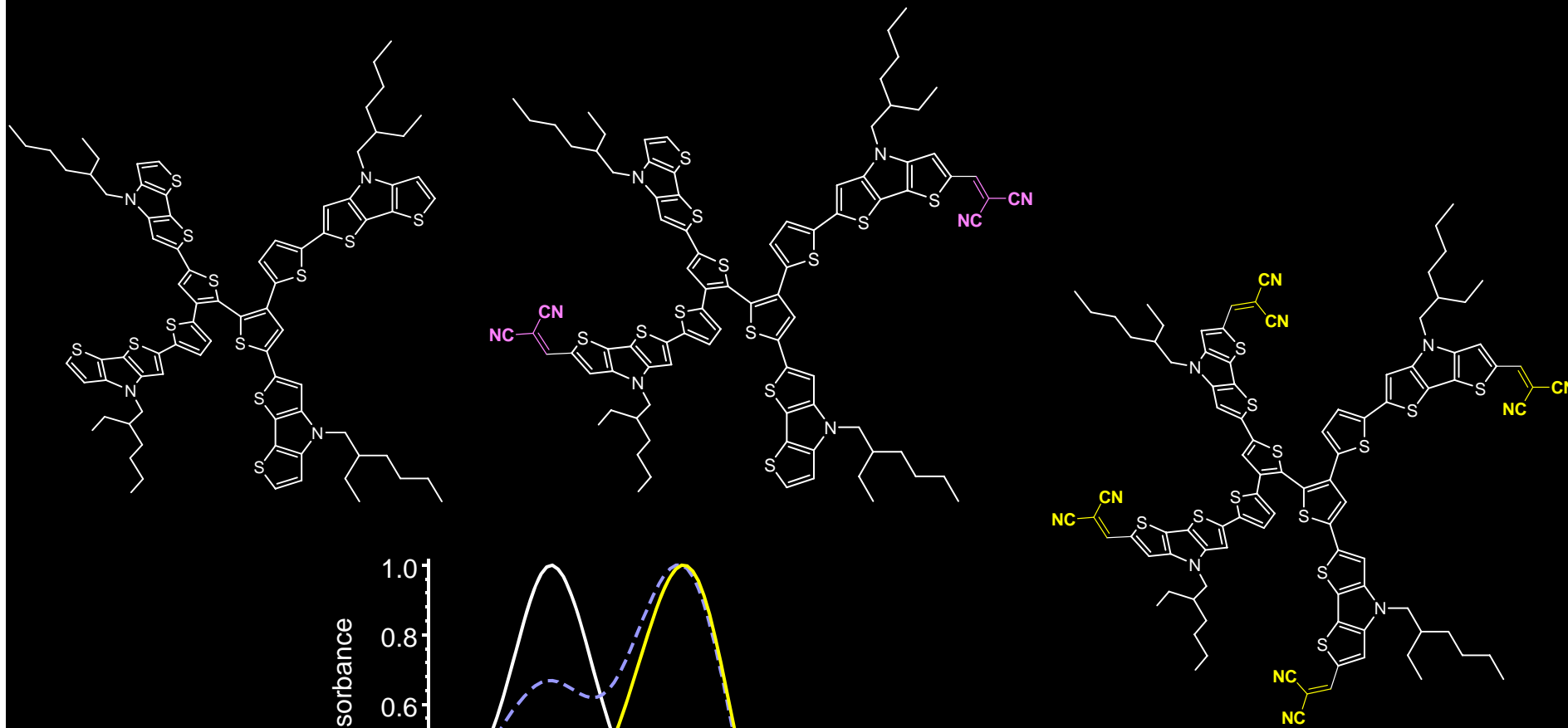
Molecular Engineering of ICT



Tests comme matériau accepteur en cours

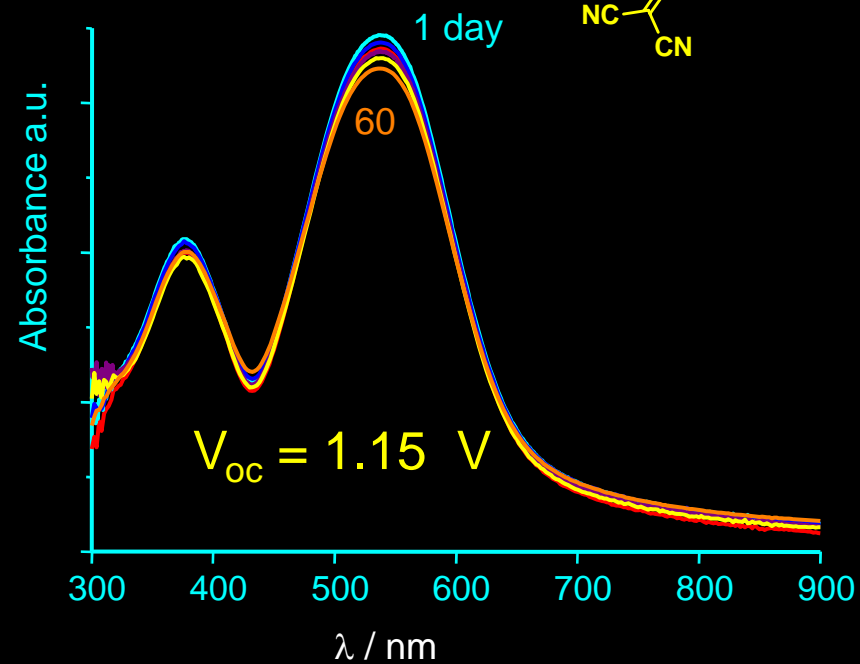
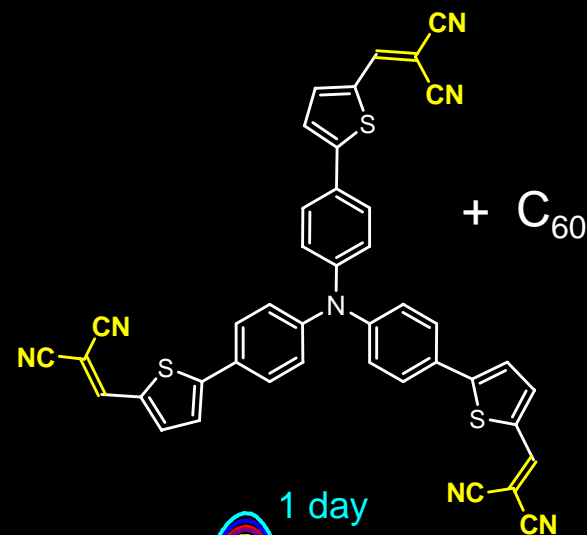
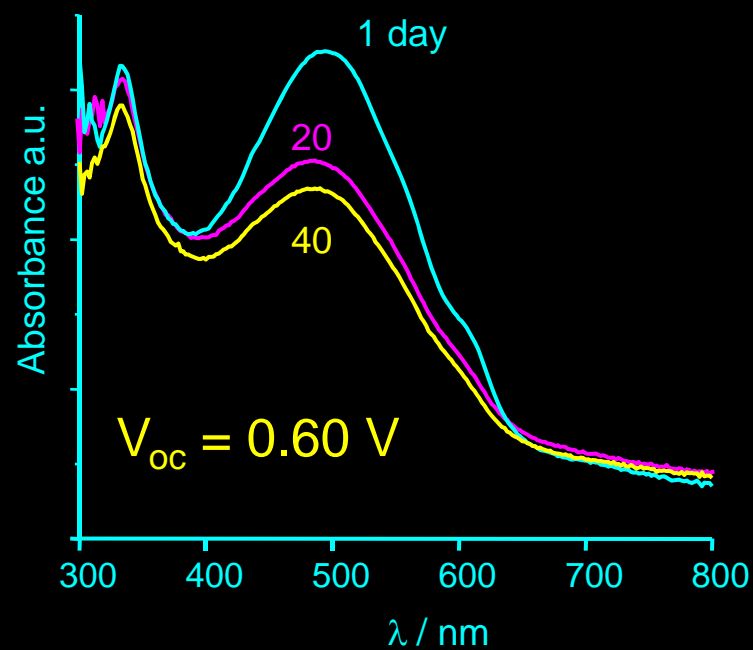
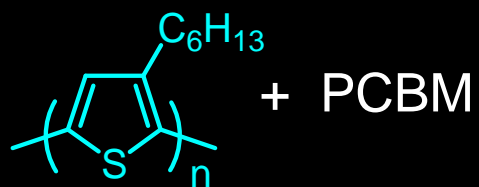
J. Org. Chem. 2007, 72, 8332

Molecular Engineering of ICT

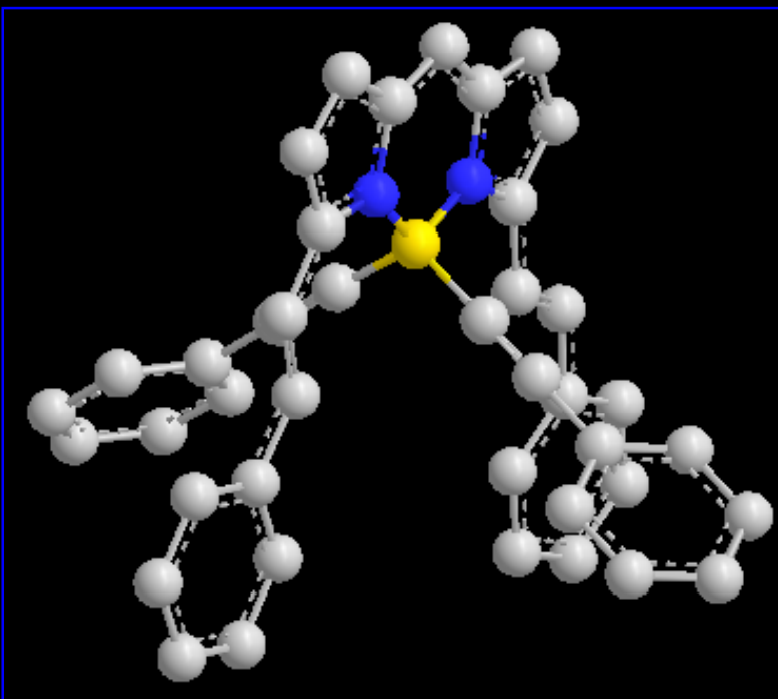
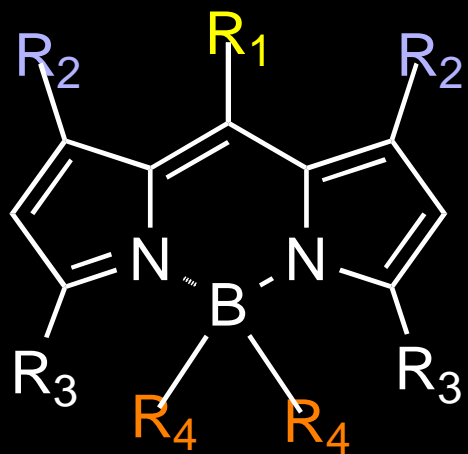


ICT and Material Stability

Non encapsulated devices stored in ambient conditions

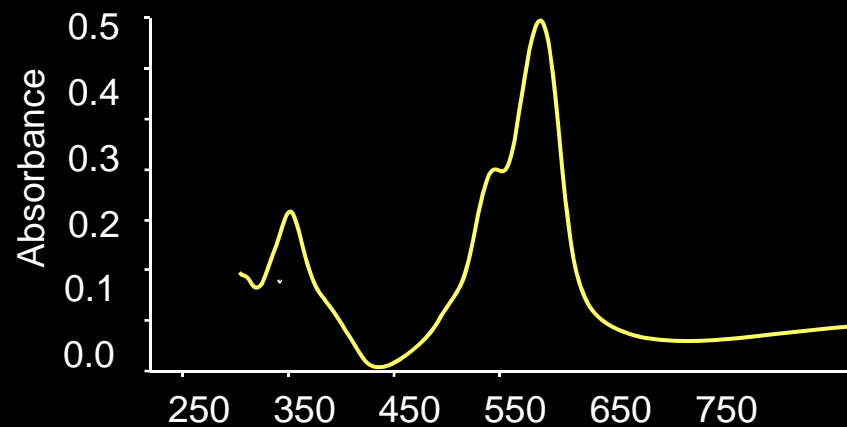
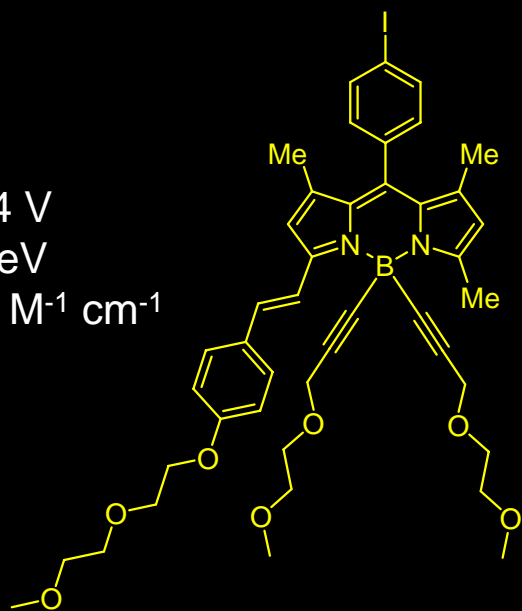


BODIPYs as 3D Donors in Molecular BHJ

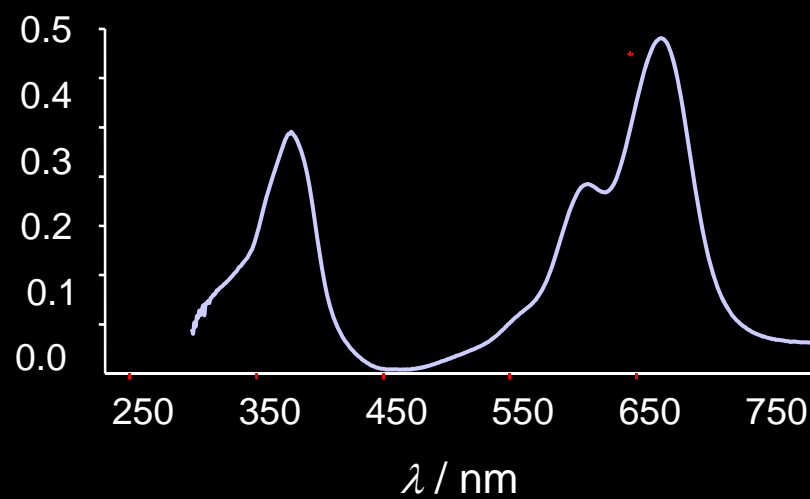
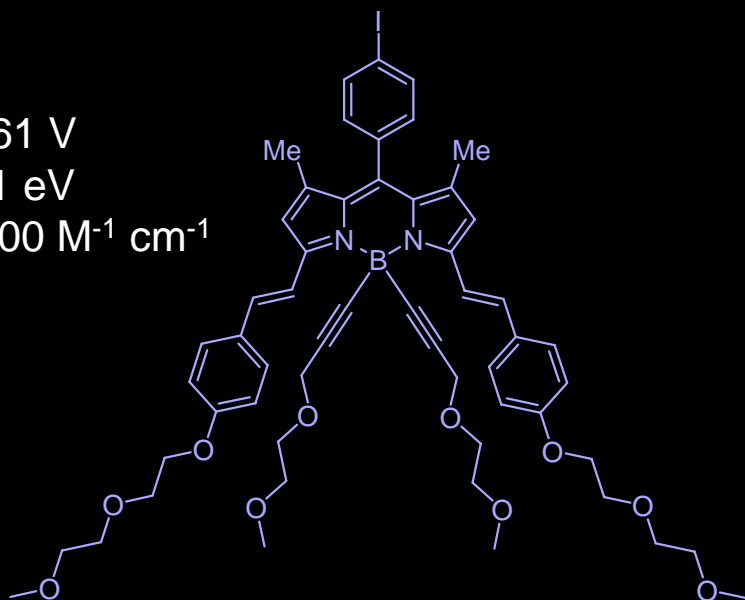


- High absorption coefficients
- High luminescence efficiency
- Photostability

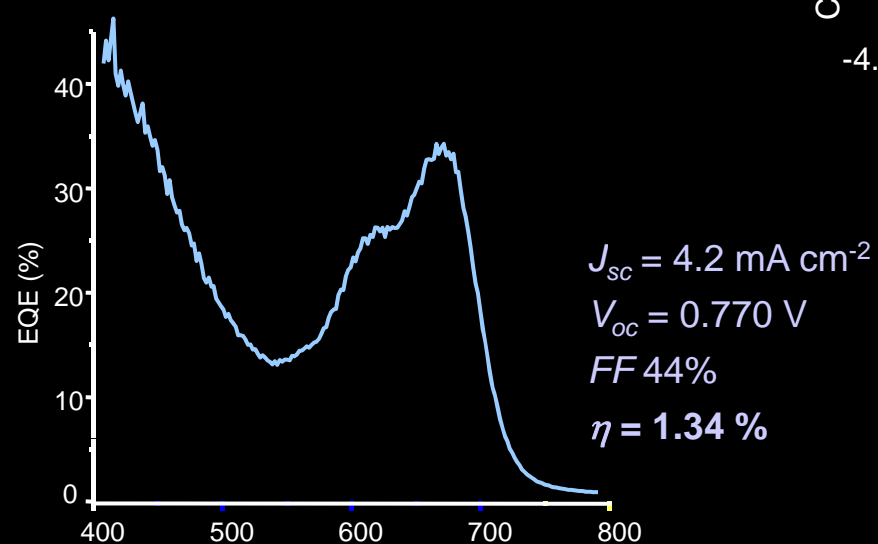
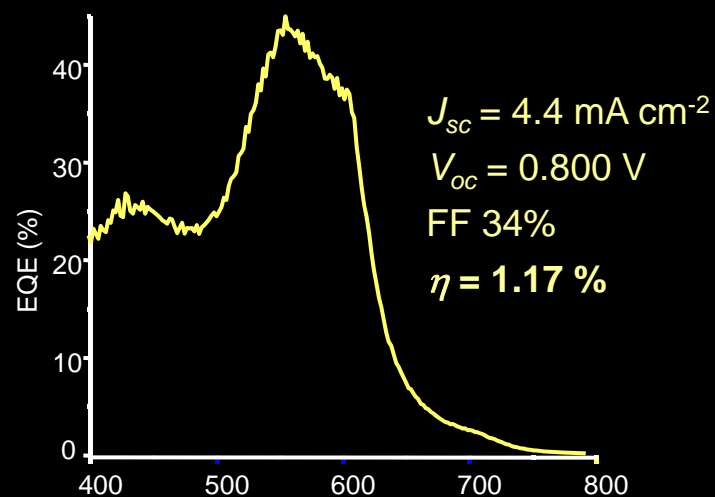
$E_{OX} = 0.74 \text{ V}$
 $E_g = 2.11 \text{ eV}$
 $\varepsilon = 93500 \text{ M}^{-1} \text{ cm}^{-1}$



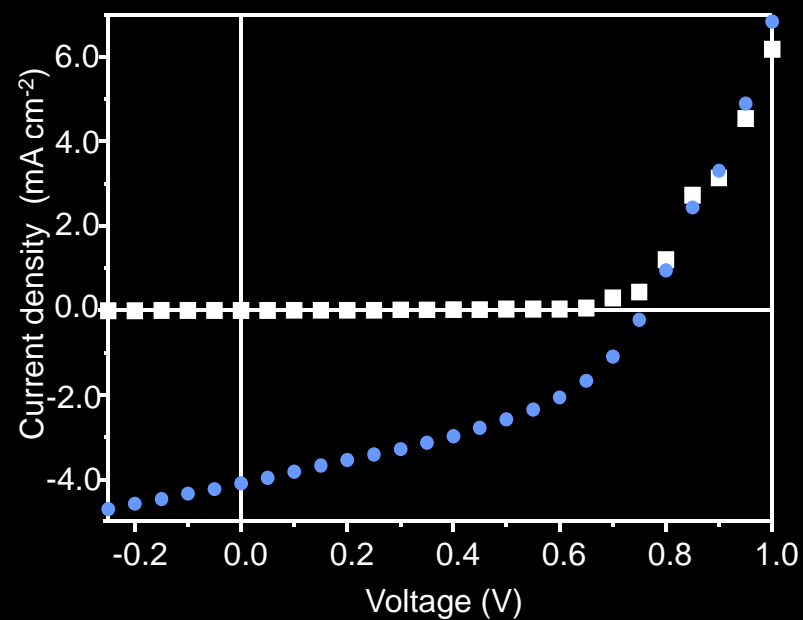
$E_{OX} = 0.61 \text{ V}$
 $E_g = 1.81 \text{ eV}$
 $\varepsilon = 126000 \text{ M}^{-1} \text{ cm}^{-1}$



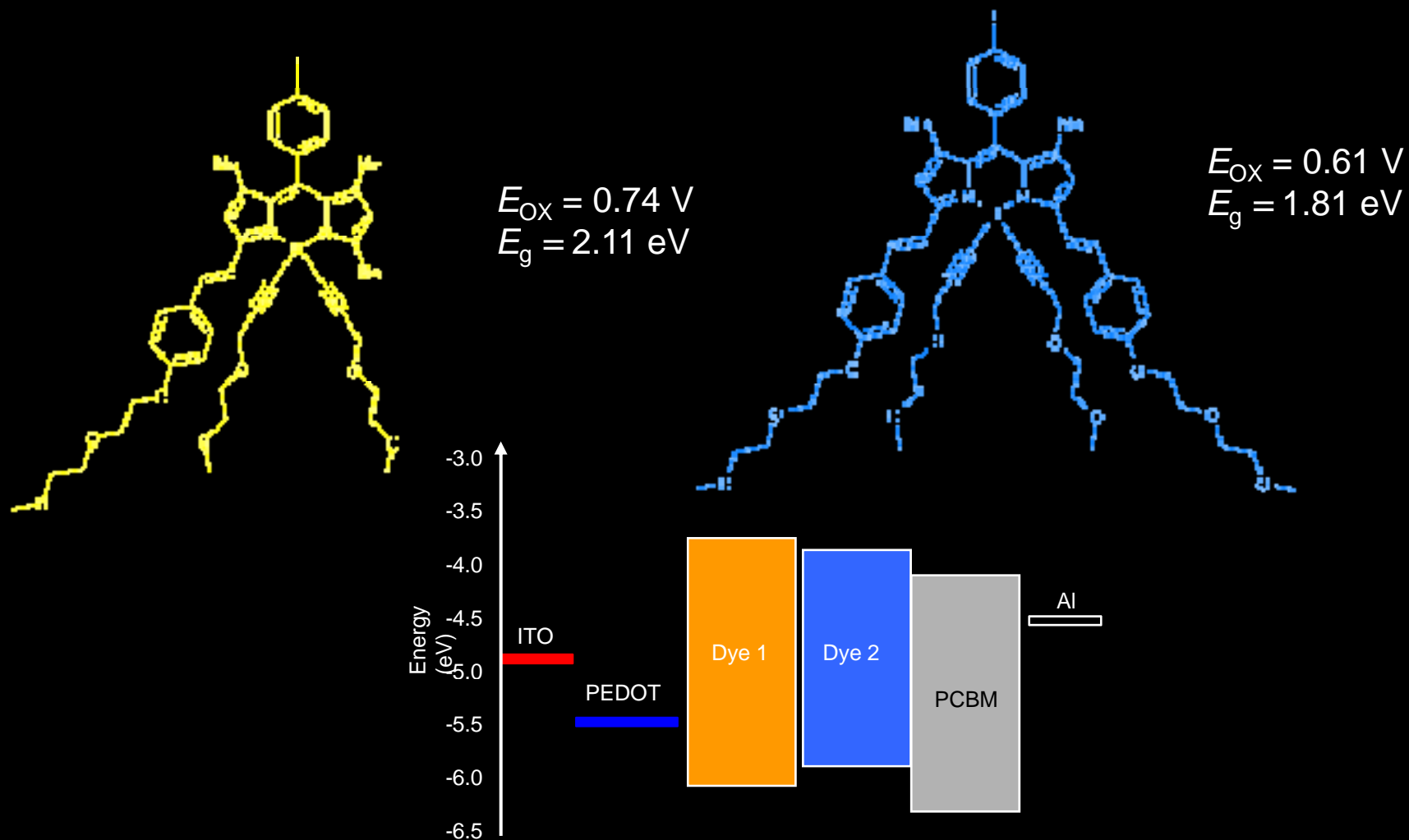
BODIPYs as Donors in Molecular BHJ Solar Cells



Donor / PCBM = 1:2, 100 mW cm⁻²

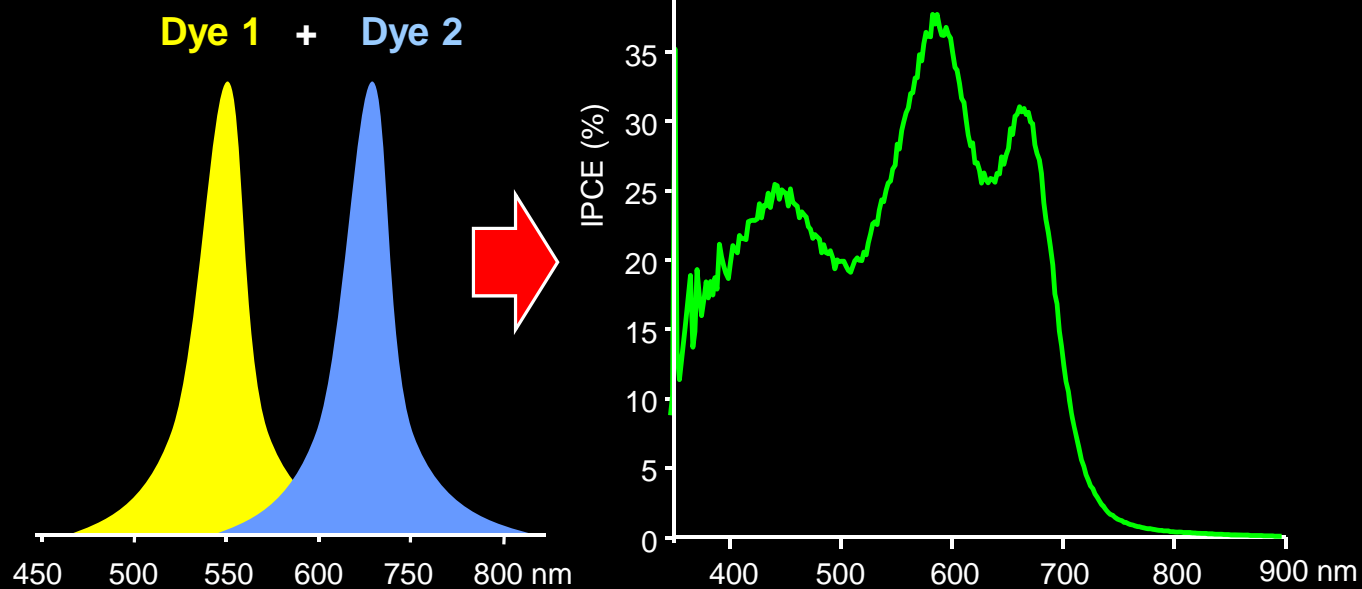


Towards Multi-donor Molecular BHJ Solar Cells



Possible photoinduced electron transfer from each dye to C_{60}

Multi-donor molecular bulk heterojunctions



First evidences for additivity

$$J_{sc} = 4.7 \text{ mA cm}^{-2}$$

$$V_{oc} = 0.87 \text{ V} \quad \eta = 1.70\%$$

Conclusions

- BHJ à base de donneurs moléculaire de structure chimique définie et reproductible (Nguyen 4.4% Octobre 2009)
- Donneur à ICT : réponse spectrale, voltage, stabilité
- BHJ multi-donneurs

Bilan

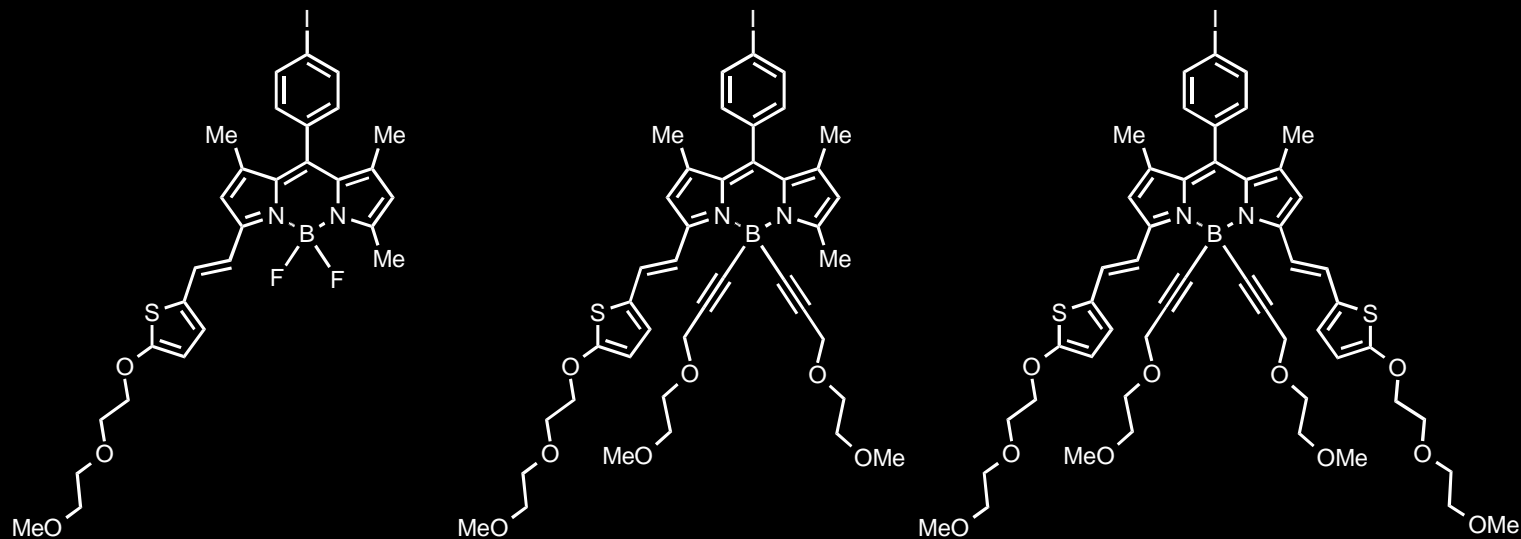
- P. Leriche, N. Cocherel, E. Ripaud, P Frère, J. Roncali, *New J. Chem.* 2009, 33, 801
- T. Rousseau, A. Cravino, T. Bura, G. Ulrich, R. Ziessel, J. Roncali, *Chem. Commun.* 2009, 1673
- T. Rousseau, A. Cravino, T. Bura, G. Ulrich, R. Ziessel, J. Roncali, *J. Mater. Chem.* 2009, 19, 2298
- P. Leriche, F. Piron, E. Ripaud, P. Frère, M. Allain, J. Roncali, *Tetrahedron Lett.* 2009, 50, 5673.
- J. Roncali *Acc. Chem. Res.* 2009 (in press)

- Q. Bricaud, A. Cravino, P. Leriche, J. Roncali, *Solar Energy Mater. Solar Cells*, 2009, 93, 1624.
- N. Hergué, P. Frère, M. Allain, J. Roncali, *Macromolecules* 2009, 42, 5593.
- Q. Bricaud, A. Cravino, P. Leriche, J. Roncali, *Synth. Met*, 2009, (in press)

Perspectives

Développement de nouvelles générations de donneurs moléculaires

BODIPY Donors : Structure-Properties Relationships



J_{sc} mA cm ⁻²	1.60	3.04	3.46
V_{oc} (V)	0.28	0.65	0.63
FF (%)	27	28	31
η (%)	0.12	0.55	0.68