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New liquid-crystalline semiconducting (PBTTT)-based polymer : from synthesis to organic field-effect transistor properties

Dizheng LIU^a, Lydia SOSA-VARGAS^a, David KREHER^{a,b}, Fabrice MATHEVET^a

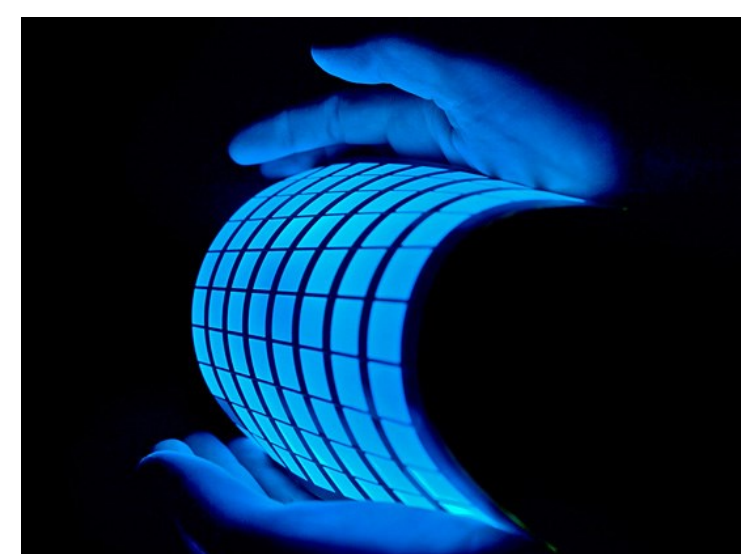
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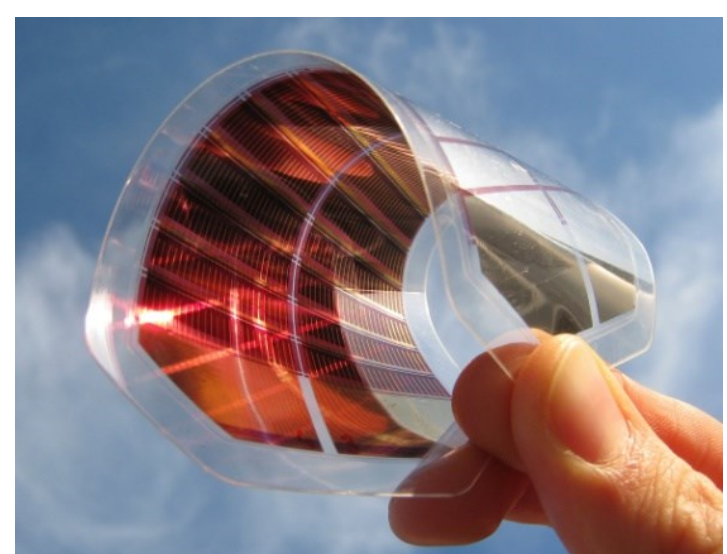
Email : david.kreher@uvsq.fr

Introduction

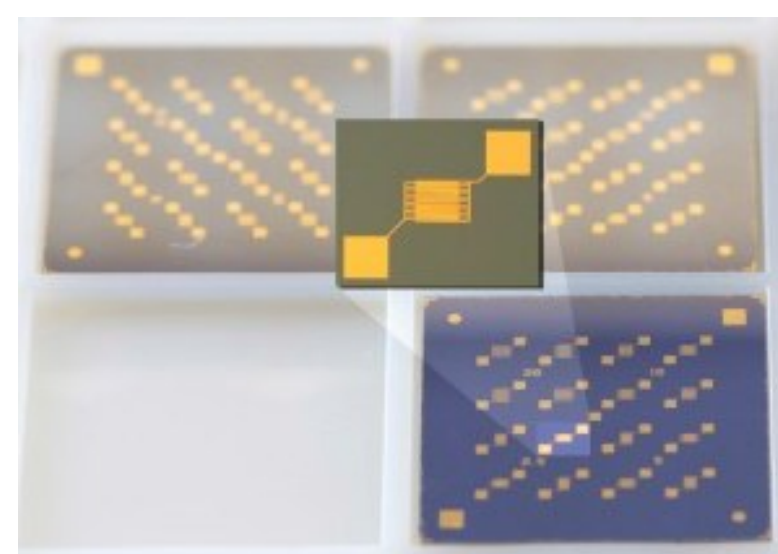
Semi-conducting materials have attracted much attention as they can be widely used as electronic devices, such as organic light emitting diodes (OLEDs), organic photovoltaic cells (OPVs) and organic field effect transistors (OFETs). The biggest challenge to improve the device's performance is to get high charge carrier mobility. One promising solution is to prepare ordered materials. Therefore, in my project, we plan to prepare a semi-conducting polymer bearing a π -conjugated liquid crystal side group, hoping that this polymer will be able to self-organize and as a result exhibit high charge carrier mobility.



Organic Light Emitting Diodes (OLED)

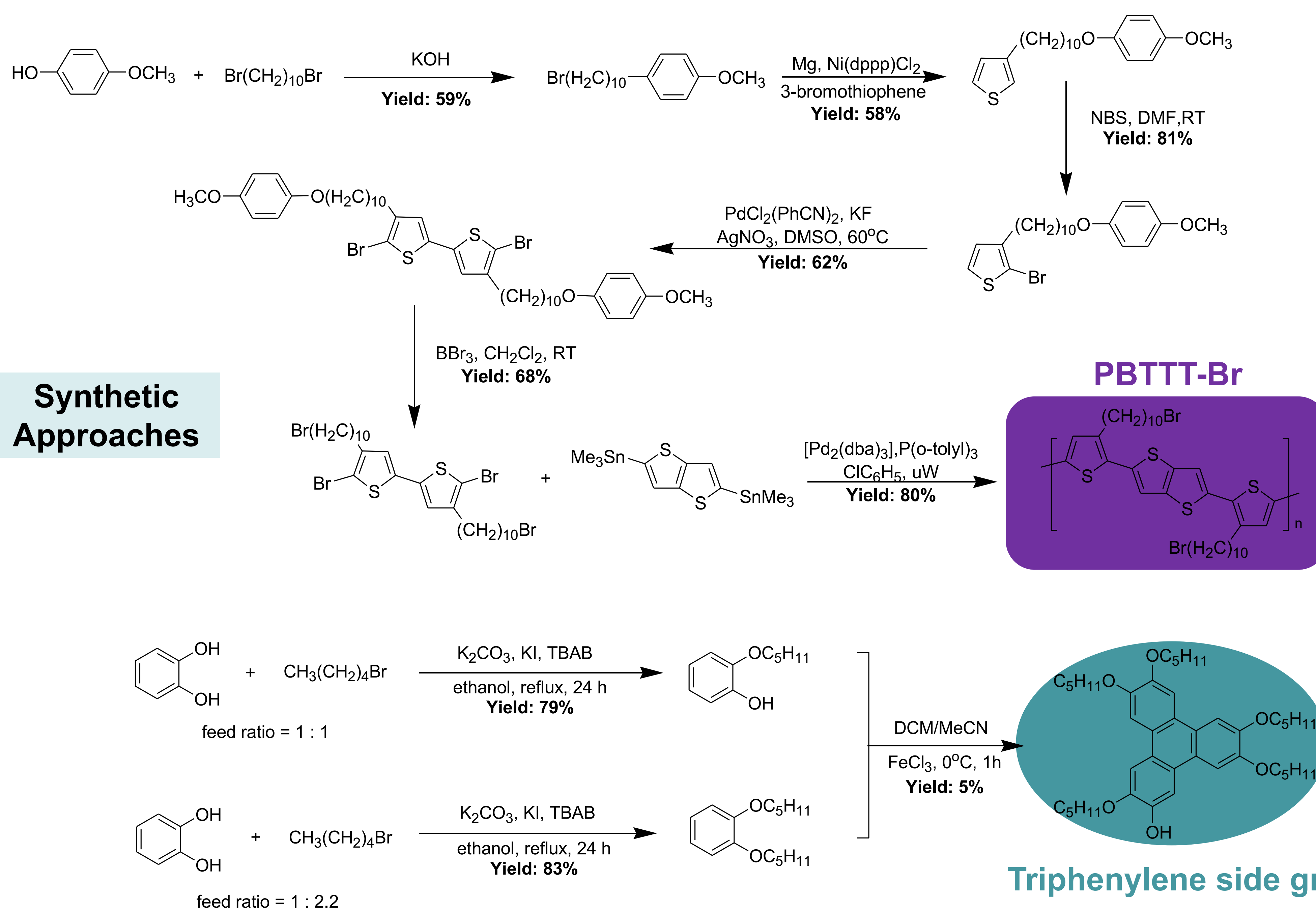
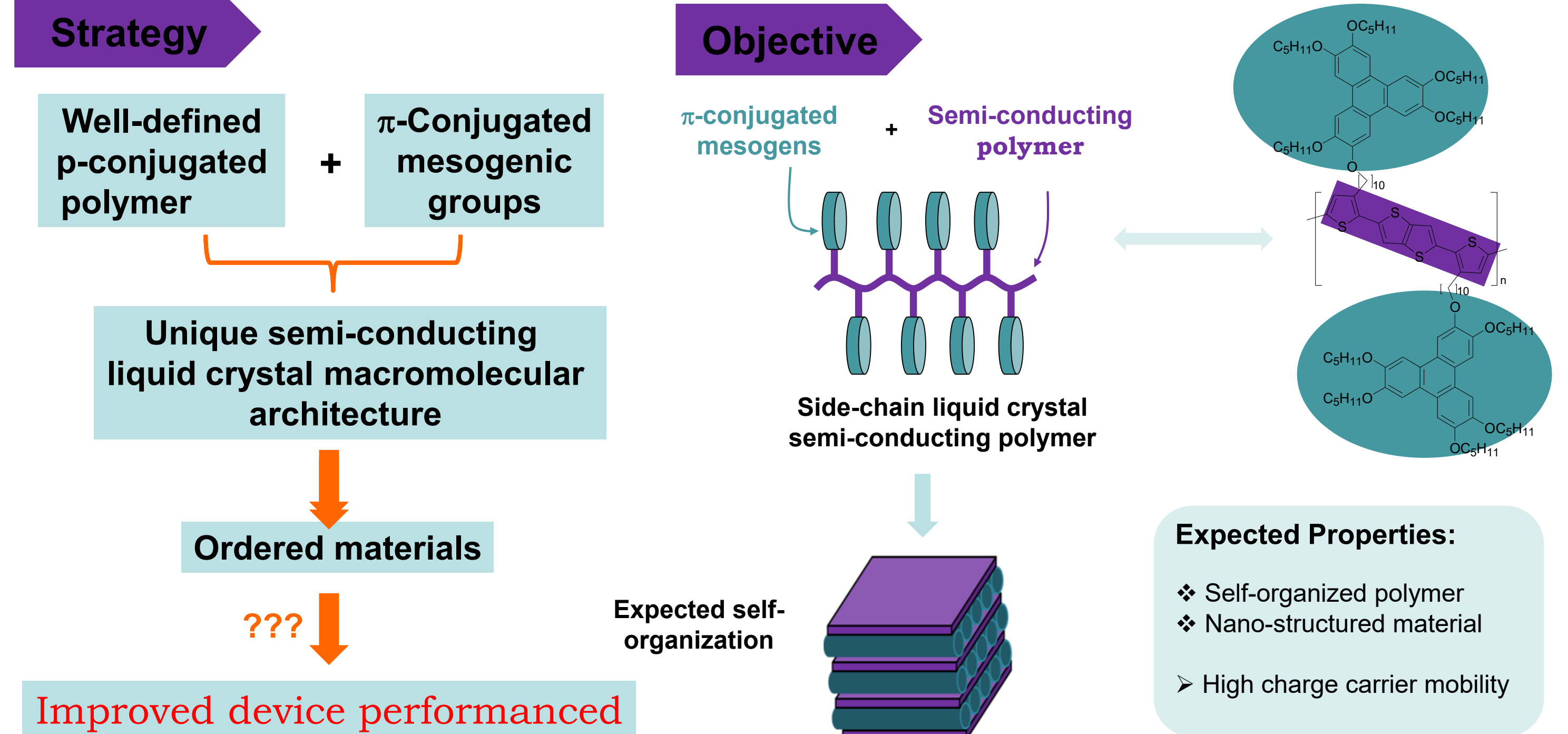


Organic Photovoltaic Cells (OPV)



Organic Field Effect Transistor (OFET)

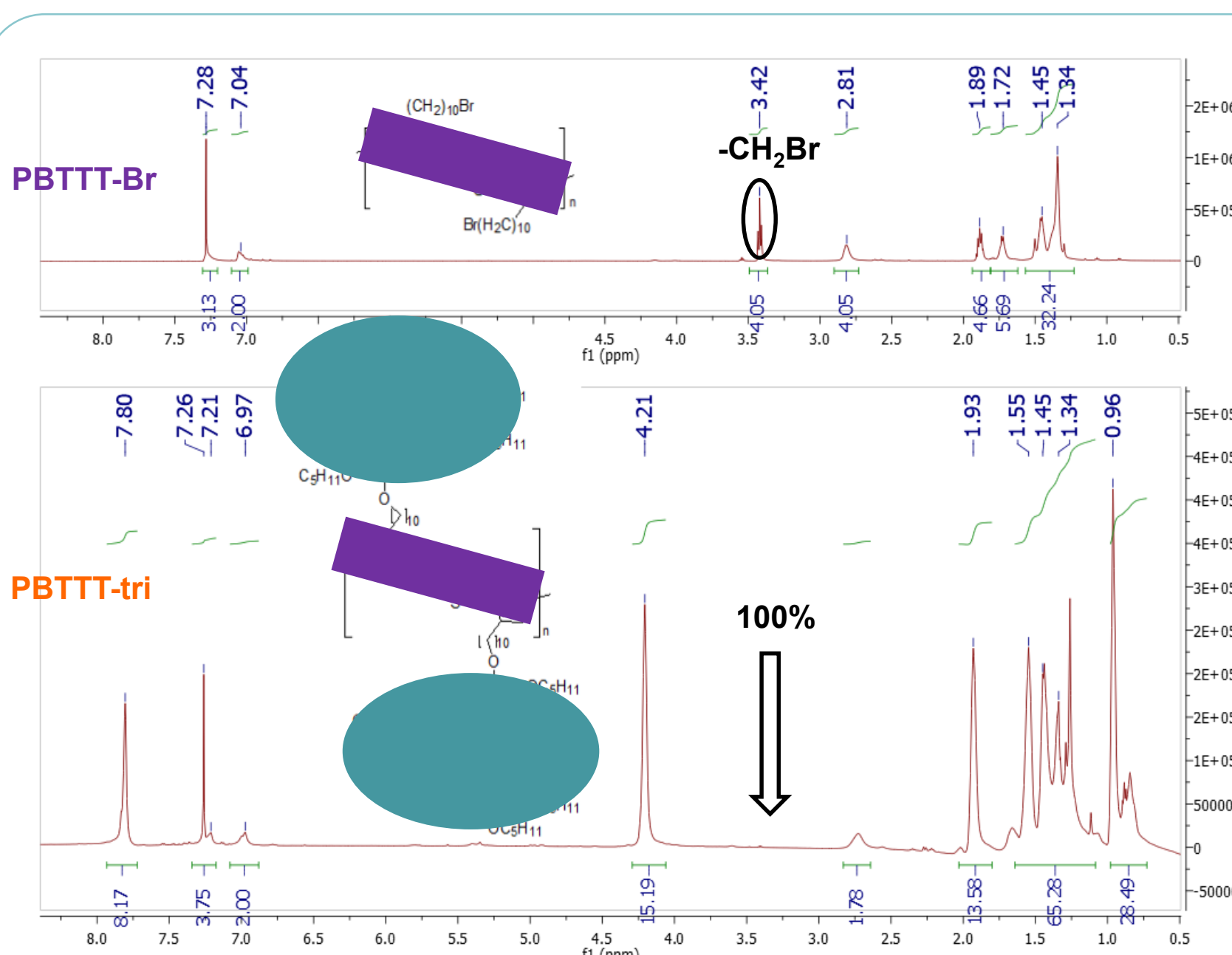
Strategy and Objective



References

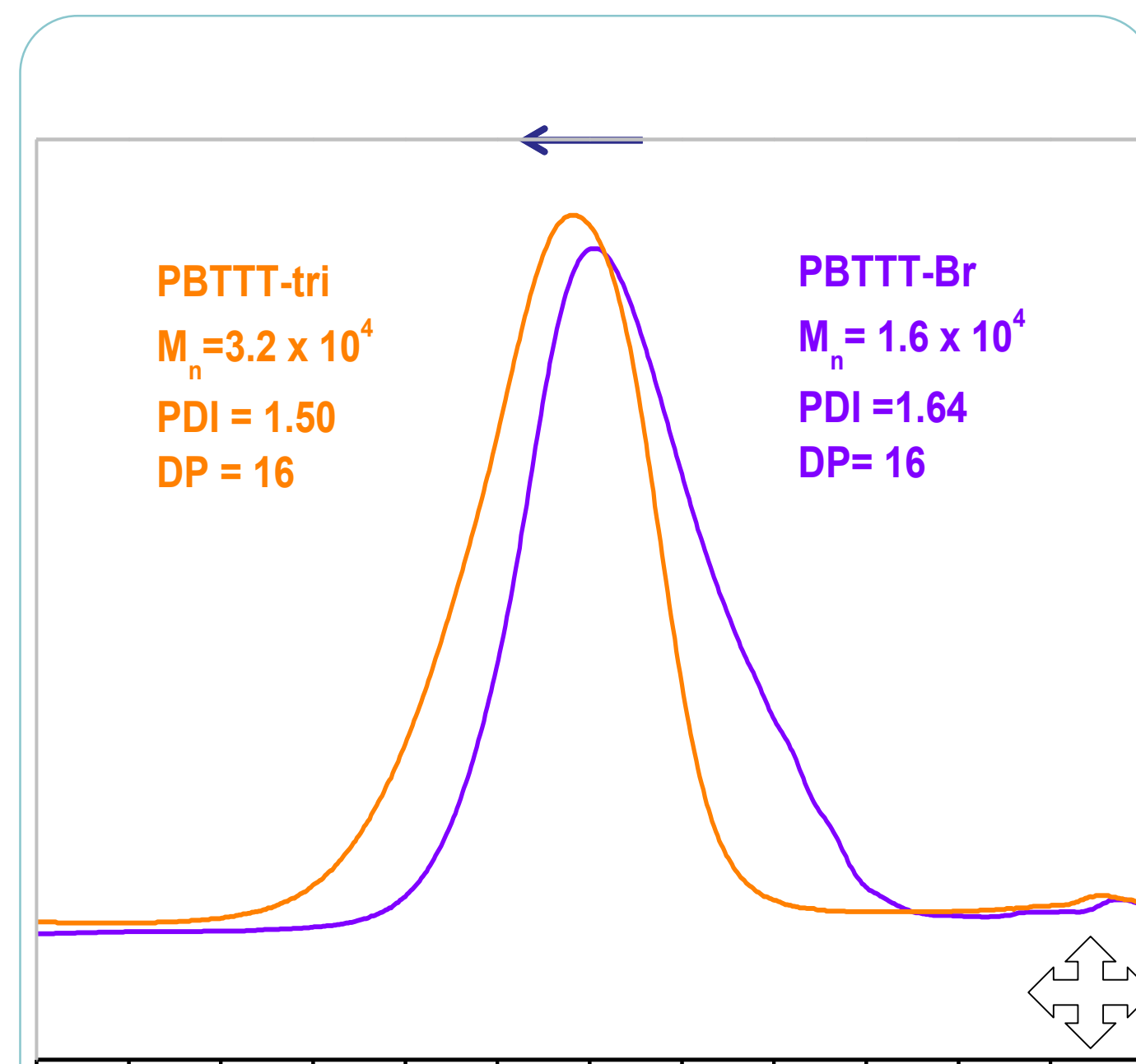
- Elbing, M.; Garcia, A.; Urban, S.; Nguyen, T. Q.; Bazan, G. C. In Situ Conjugated Polyelectrolyte Formation. *Macromolecules* **2008**, *41* (23), 9146–9155.
- Tahar-Djebbar, I.; Nekelson, F.; Heinrich, B.; Donnio, B.; Guillon, D.; Kreher, D.; Mathevet, F.; Attias, A. E.-J. Lamello-Columnar Mesophase Formation in a Side-Chain Liquid Crystal π -Conjugated Polymer Architecture. *Chem. Mater* **2011**, *23*, 4653–4656.

NMR characterization



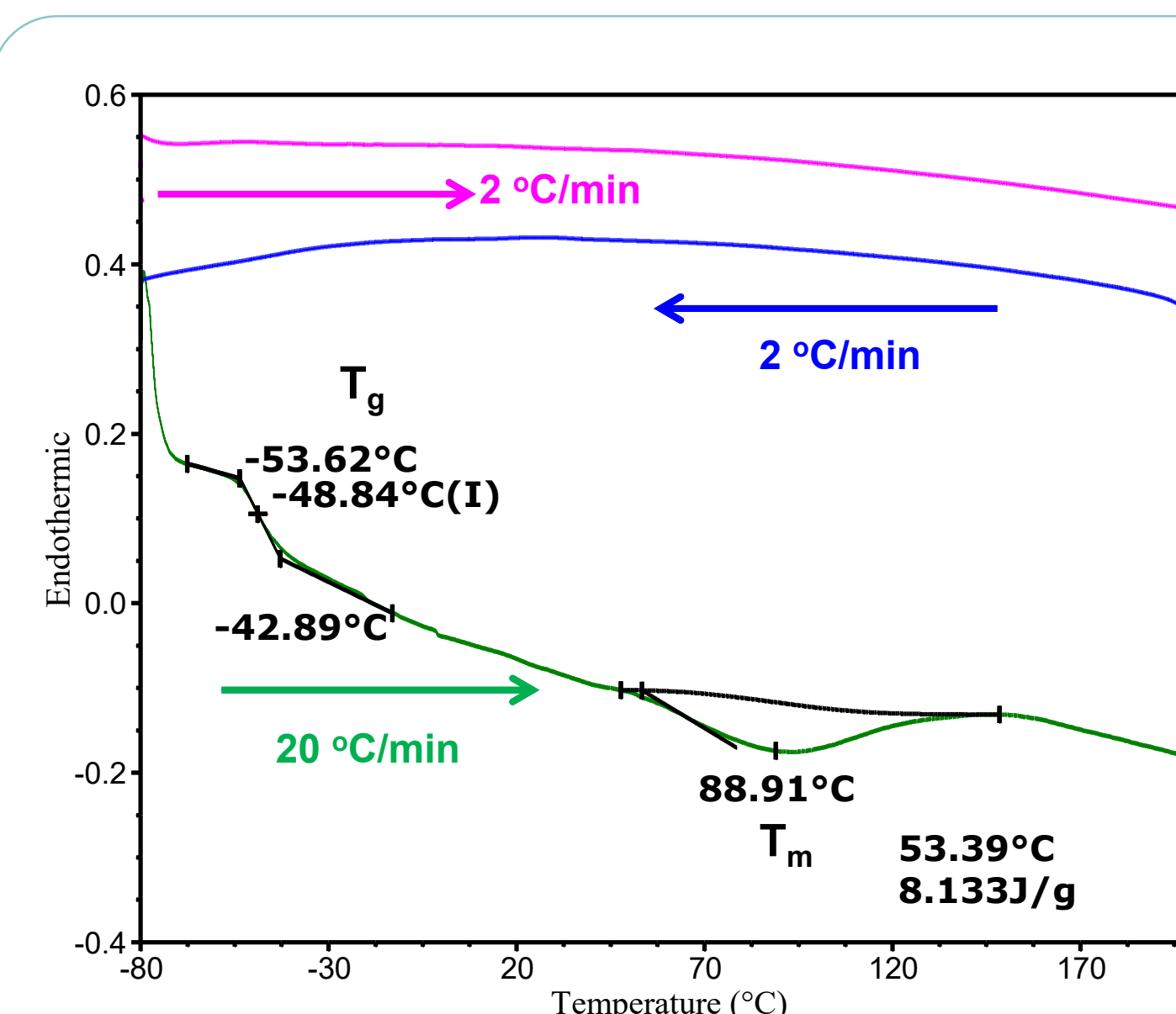
¹H NMR spectra of PBTTT-Br and PBTTT-tri. It shows that the peak of -CH₂Br of PBTTT-Br has completely vanished. This confirms that the grafting is almost complete.

SEC measurements



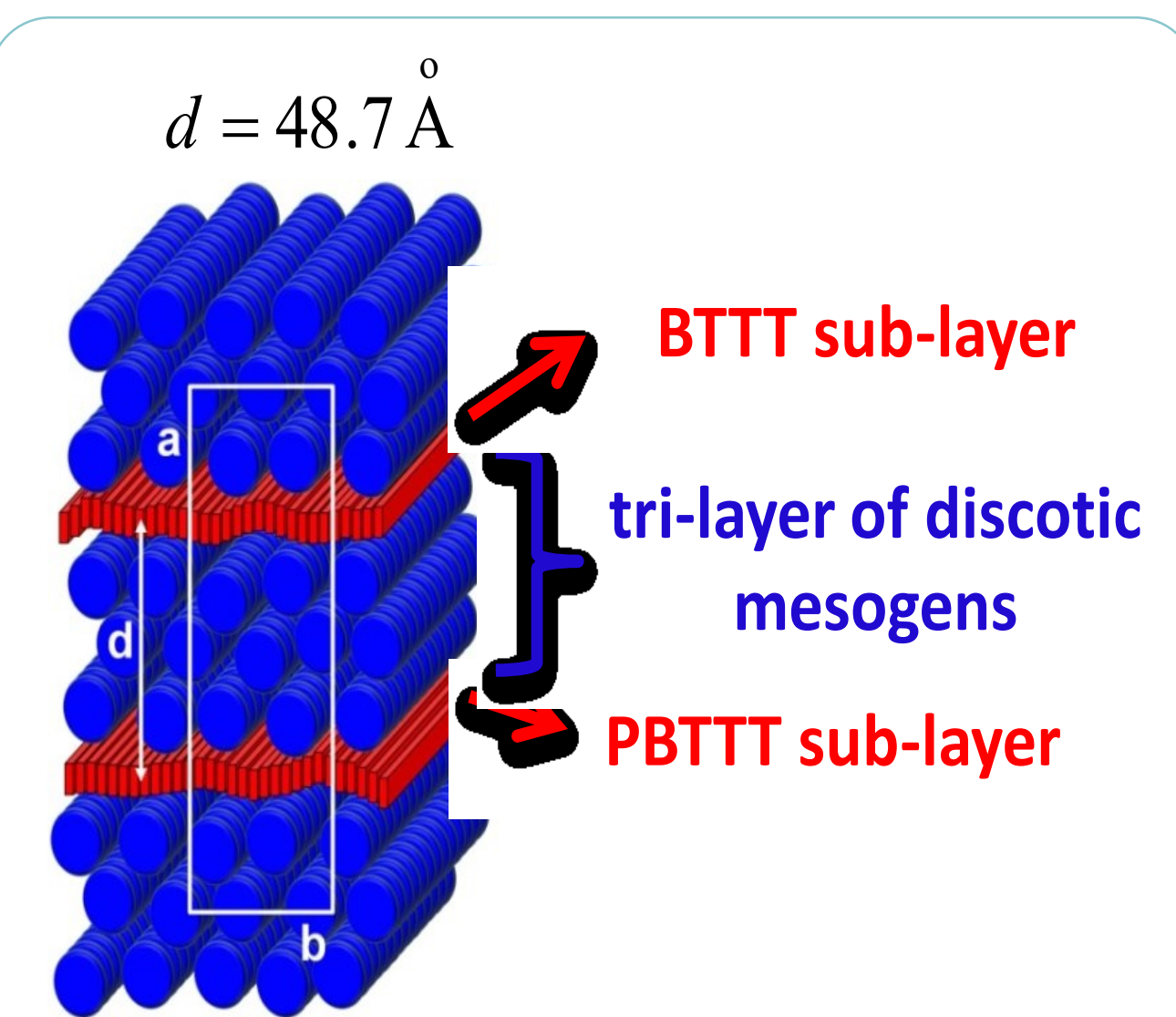
SEC curves of PBTTT-Br and PBTTT-tri. It shows the molecular weight increased after grafting.

DSC studies



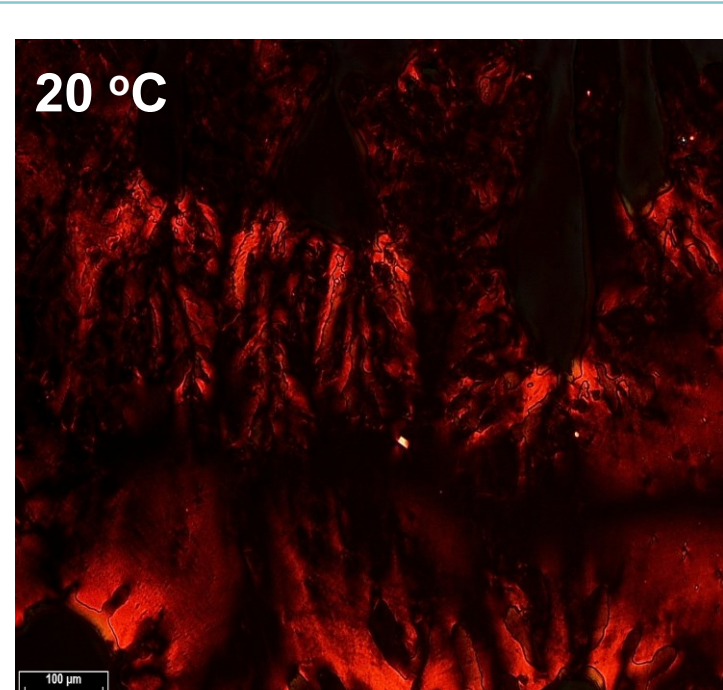
DSC traces for PBTTT-tri were recorded at rates of 2 °C/min and 20 °C/min. The glass transition (T_g) was clearly detected at around -48 °C on heating with high scanning rate (20 °C/min), and the melting temperature was at about 89 °C on heating with the scanning rate of 20 °C/min.

Self-organization



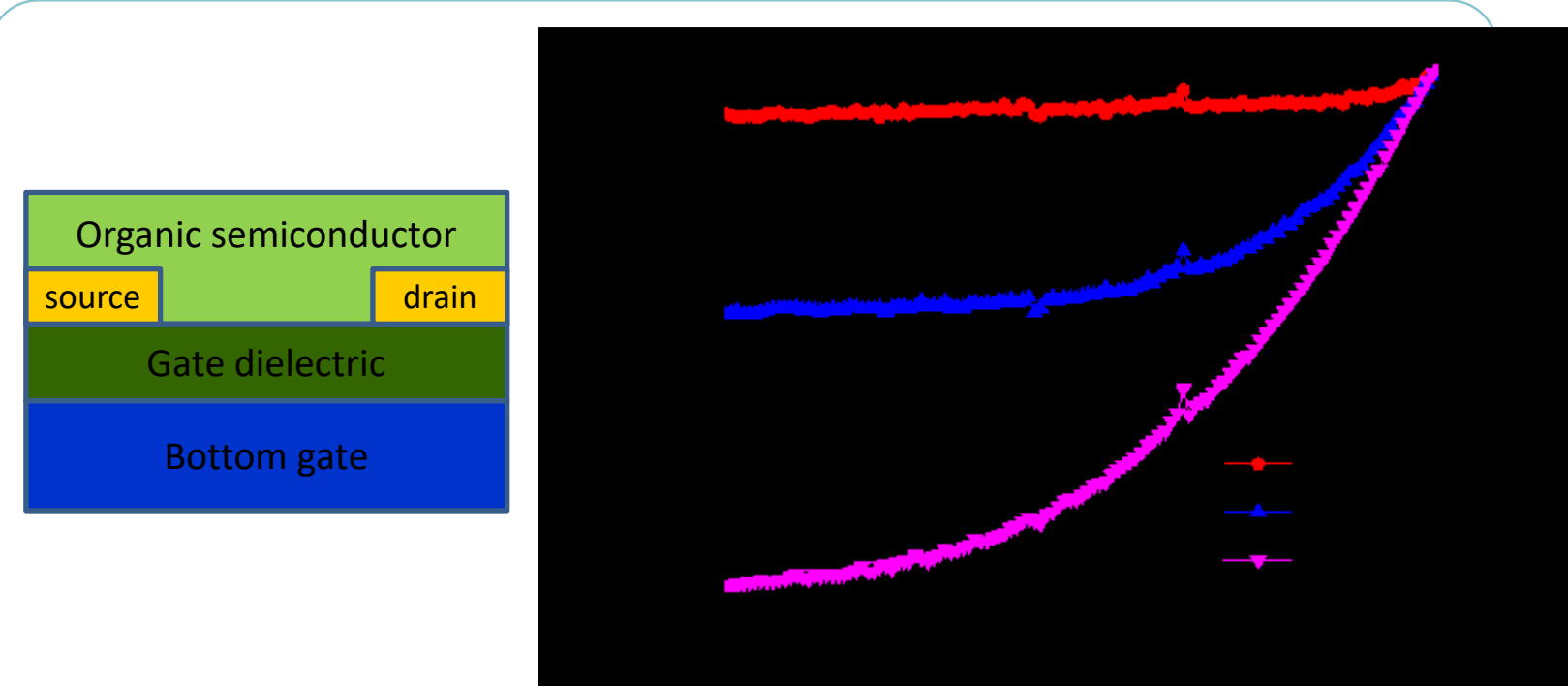
PBTTT-Tri was investigated by temperature dependent Small-angle X-ray Scattering (SAXS) and Grazing-Incidence Wide-Angle X-ray Scattering (GIWAXS). The results showed that the material presents a lamellar-columnar arrangement that can be oriented on surface

POM observation



POM micrograph of PBTTT-tri was obtained at room temperature and it exhibits birefringence, which indicates the existence of mesophase.

Preliminary OFET mobilities



Preliminary charge transport properties in OFET BCBG (= bottom contact bottom gate) configuration gives $\mu_{h+} = 1.2 \times 10^{-5} \text{cm}^2/\text{Vs}$ (p-type transistor)

Conclusion

The obtained polymer (PBTTT-Tri) was synthesized via a post-functionalization strategy. Before to be characterized by appropriate analytical techniques (¹H NMR, ¹³C NMR and SEC). Then its thermal behavior was studied by Polarized Optical Microscopy (POM) and Differential Scanning Calorimetry (DSC). The self-organization property of PBTTT-Tri was also investigated by temperature dependent (SAXS) and (GIWAXS). We evidenced this material presents a lamellar-columnar arrangement that can be oriented on surfaces. Moreover, the preliminary charge transport properties of PBTTT-Tri in thin films were examined in OFET configuration, and a p-type conduction with a hole mobility around $1.2 \times 10^{-5} \text{cm}^2 \text{V}^{-1} \text{s}^{-1}$ was observed.