Solution-processing of charge transfer organic semiconductors for n-type field effect transistors

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INTRODUCTION

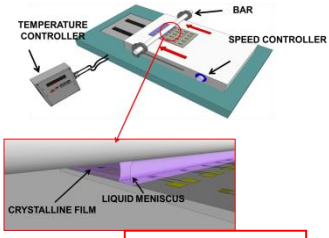
Charge transfer (CT) complexes have attracted great attention because of their potential as a new type of organic semiconductors material. Organic charge-transfer salts are formed from electron acceptors (e.g. tetracyano-quino-dimethane, TCNQ) and electron donors (e.g. tetrathia-fulvalene, TTF), and provide a new material with new physical properties. However, their application in organic electronics (OEs) has been mainly limited to ideal single crystals or to films prepared by the co-evaporated of their components. Herein, we prepared organic field-effect transistors (OFET) of the CT salt based on C8-O-BTBT-O-C8 /F4TCNQ by a simple solution shearing technique (i.e., BAMS).

Strategies:

- Gate/Substrate: Si/SiO_2
- Active layer :(C_8-O-BTBT-O-C_8:$TCNQF_4$):PS_{100k}
- Ink Formulation: OSC 4: 1 PS in (CB:BN)
- Source/Drain: Au/ PFBT-SAM
- Bar-assisted meniscus shearing (BAMS)

BAMS coating technique:

The BAMS has revealed to be a powerful approach for the fabrication of OFETs at low cost anf high speed.



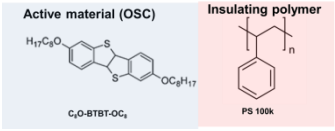
- T = 85 ºC
- Speed 2 mm/s

A solution of the semiconductor and an insulating polymer is placed between a bar and a heated substrate forming a menisucs. Such meniscus is then sheared by the movement of the bar and a dry thin film is deposited.

Experimental setup:

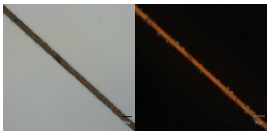
OFET devices were fabricated into Si/SiO2 with interdigitated Cr/Au electrodes, patterned by photolithography and deposited by thermal evaporation.

Thin films were deposited at ambient conditions by the BAMS technique using a home-designed bar coater. The ink was prepared by blending the active materials with polystyrene to promote film processability, reproducibility and stability. The resulting OFET devices, fabricated and measured in environmental conditions, exhibited an n-type behavior.



RESULTS AND DISCUSSION

Charge Transfer Crystals

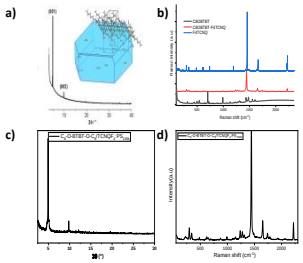


Optical (left) and POM (right) images of the C8O-BTBT-OC8/F4TCNQ crystals

The dark needles are a bit thick. They look well oriented, but it is well evident the presence of small white/transparent crystals(C_8O-BTBT-OC_8) attached to the CT needle.

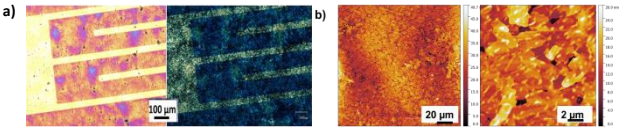
Raman and XRD Characterization

The structure of the thin film matches the structure of the single crystal .



XRD diffractgrams of C8-O-BTBT-O-C8/TCNQF4 (a) crystal and (c) thin film and (b) Raman spectrum of the C8-O-BTBT-O-C8/TCNQF4 (b) single crystal and (d) thin film

Charge tranfer thin film

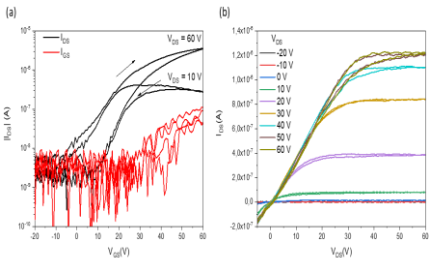


a) Optical polarized microscopy images and b) AFM images of the thin films. C8-O-BTBT/TCNQF4)/PS_{100k} films deposited at 2 mm/s at substrate temperature of 85 º .

Small polycrystalline domains was observed at optical polarized microscopy images and no preferential orientation relative to the shearing direction was observed. The topography AFM images provide information about the stratification of the films. And the microcrystals was observed.

An excellent homogeneity and crystallinity of the semiconductor is successful obtained by combining C8-O-BTBT-O-C8/TCNQF4 :PS blends with BAMS.

Transistor characterizations:



Our OFET devices present a field effect mobility (µ) of the order opf 10^{-3} cm^2/Vs , a low threshold voltage (V_{TH} close to 0 V) and a high on/off ratio. However the device performance shows a significant hysteresis that can be attributed to a high number of interfacial charge trap density.

Electrical characterization a) transfer and b)output measurements of the (C8-O-BTBT:TCNQF4): PS (4:1) OFETs in Air .C8-O-BTBT/TCNQF4)/PS_{100k} films deposited at 2 mm/s at substrate temperature of 85 ºC

CONCLUSIONS

• Thin films of the CT complex **C8-O-BTBT/$TCNQF_4$** blended with **PS** were fabricated implementing a low cost and solution shearing technique.

• Structural, spectroscopic and morphological characterization of the fabricated devices confirmed the formation of a homogeneous film with no preferential molecular orientation with respect to the substrate plane.

• The prepared devices display n-type transport in air with mobility values around 10^{-3} cm^2 V^{-1} s^{-1}.

• The role of the **PS** binding polymer has been already demonstrated, which is promoting thin film processability and electron transport stability under environmental conditions.

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