HETEROCIRCULENES AS A NEW CLASS OF ORGANIC SEMICONDUCTORS

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Organic semiconductors (OSC) have attracted considerable attention in recent years for applications in electronic and optoelectronic devices such as light-emitting devices (LEDs), field-effect transistors (FETs) and photovoltaic cells.[1] Low processing cost and the mechanical flexibility of organic materials makes them compatible with plastic substrates for lightweight, low cost and foldable products including radio frequency identification tags, portable sensors, electronic paper, flat panel displays, etc.[2] While the charge carrier mobilities achieved for some OSCs already rival that of amorphous silicon, the long term operational and storage stability, which is inherently linked to the molecular structure, is still limiting wide implementation of OFETs. Therefore, design of new stable organic semiconducting materials is of great practical interest. Pentacene and its derivatives, as well as linear oligo- and polythiophenes have been the two most studied classes of materials in OSC.[3]

In this work, we have demonstrated applicability of the first all-heterocyclic octathio[8]circulene (sulflower) and its selenium analogue tetraselenatetrathio[8]circulene (selenosulflower) as a semiconductor through successful fabrication of Organic Thin Film Transistors (OTFT) with these materials. We showed that heterocirculenes can be potentially used as *p*-type semiconductors in nanoelectronics. For vacuum deposited films of both materials, we carried out electronic characterizations in FET configuration. Highest hole mobility of 9×10^{-3} cm^2/Vs and 1×10^{-3} were achieved for sulflower and selenosulflower, respectively. Atomic Force Microscopy (AFM) was used to visualize the morphology of the films grown at different surface coverage and to determine the organization of the molecules. We also employed X-Ray Diffraction (XRD) spectroscopy to reveal information about the crystallographic structure and physical properties of thin films.

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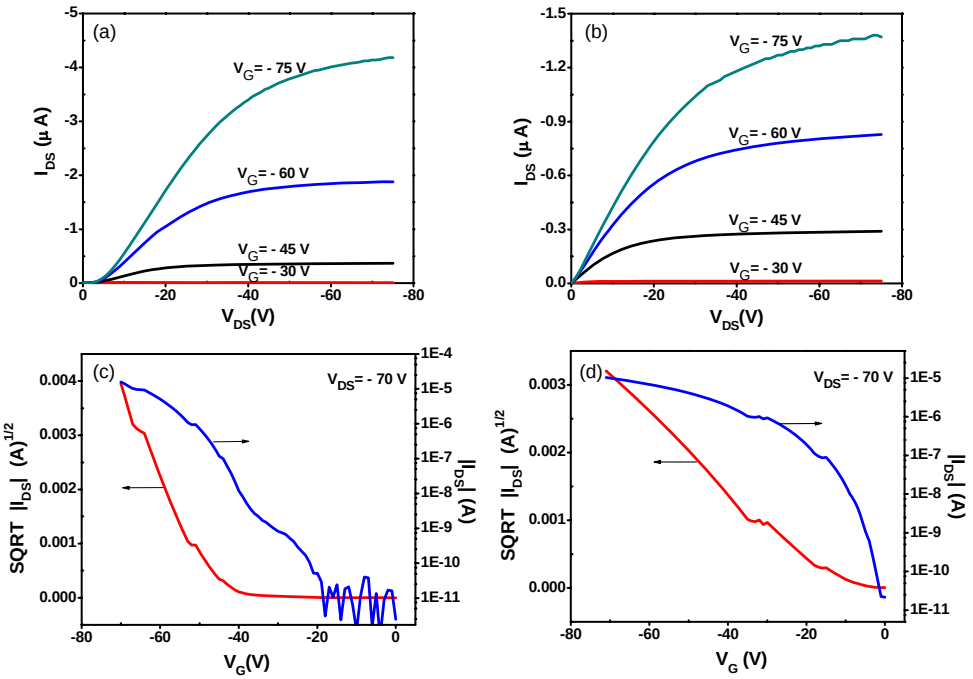

Figure 1: (a) and (b) output characteristics of bottom-contact OFET of sulfower and tetraselenotetrathio[8]circulene, respectively, (c) and (d) transfer characteristics of bottom-contact OFET of sulfower and selenasulflower, respectively. (deposition rate =0.2 Å/s, nominal thickness ~ 36 nm, W/L=1880/6 μm/μm). I_{DS} is the drain-source current and V_{DS} and V_G are the biasing voltages of drain-source current and gate electrodes, respectively.

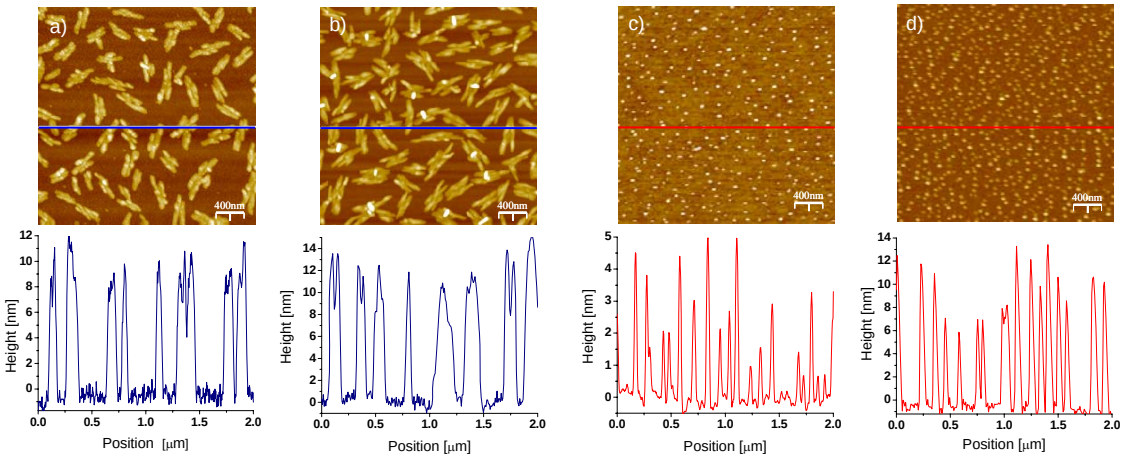

Figure 2: AFM Micrograph (2 μm×2 μm) images of thin films of sulflower (a, b) with the deposition time of 1 min, 2 min, respectively; tetraselenotetrathio[8]circulene (c,d) with the deposition time of 1min, 2 min, respectively. Films grown on SiO_2/Si substrate at room temperature (deposition rate=0.2 Å/s).