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## PhD Abstract

### **Oligomeric Crystalline Materials for Organic Field Effect Transistor Applications**

The aim of this work is to manufacture field effect transistors with active channels from organic materials (organic FET, OFET), their examination and comparison of their characteristics with other similar organic devices and silicon FETs.

We investigate the class of metal phthalocyanine salts (MePCs, Me=Ni or Co) and metal phthalocyanine sulfonate sodium salts (MePCS<sub>x</sub>s, Me=Ni, Co, Cu, Zn or Al) as candidates for *p*-type channels in organic transistors. Both kinds have the advantage of chemical and thermal stability. MePCs are interesting for electronic applications such as chemical sensors and solar cells. MePCS<sub>x</sub>s are selected because of their enhanced solubility compared to their non-sulfonated counterparts.

The comparison between the MePCs studied is based on their electric behavior depending on a) the method of deposition, b) the type of metal and c) the presence or not of pendant groups. The objective is to select the type of material and the film preparation process with the optimal performance.

Metal phthalocyanine sulfonate sodium salts, are innovative materials, which can be used to construct OFETs with much less effort. The processes are much simpler and the mobilities arising much higher. In that case, the film that serves as the semiconducting layer is prepared by spin coating at room temperature, using aqueous solutions.

MePC systems are studied for comparison with previous results. The values found by our group fall in the same range and are acceptable for the applications to which those materials address.

In the case of metal phthalocyanine sulfonate sodium salts the mobility values obtained are higher, and the operating voltages required are much lower ( $V_d < 1V$  and  $V_g < 10V$ ). The drain source conductivity increased with negative gate bias indicating typical  $p$ -type conductivity. OFETs with MePCS<sub>x</sub>s as the active channel cannot be fabricated by evaporation, since the material tends to burn out before it evaporates. Furthermore the current-voltage characteristics depend strongly upon the degree of sulfonation, which has to be controlled in order to optimise device performance. For example, in the case of NiPCS<sub>1.3</sub>  $\mu = 1.08 \text{ cm}^2/V \text{ s}$ ,  $V_{th} = -0.8V$  and  $I_{ON}/I_{OFF} = 5 \times 10^3$ , whereas in the case of NiPCS<sub>3.3</sub>  $\mu = 0.02 \text{ cm}^2/V \text{ s}$ ,  $V_{th} = -1.42 \text{ V}$  and  $I_{ON}/I_{OFF} = 10^3$ . NiPCS<sub>1.3</sub> demonstrated a transconductance value of  $0.75 \times 10^{-4} S$ , significantly higher than that reported in the case of hydrogenated amorphous silicon transistors ( $\sim 10^{-6} S$ ). The channel conductivity is  $0.1 \text{ S/cm}$  giving rise to currents in the limits of mA. The increase of sulfonation (NiPCS<sub>3.3</sub>) results in inferior device performance, because the ohmic part of the  $I_d - V_d$  curve becomes more prominent while the transconductance is lower than in the NiPCS<sub>1.3</sub> case, being  $0.3 \times 10^{-7} S$ . This situation is analogous to that of polyelectrolyte-gated OFETs. In our case the Na<sup>+</sup> counterions present in the channel contribute to the device characteristics. When a negative voltage is applied to the bottom gate a part of these ions accumulate to the interface and also close to the drain electrode thus inducing electrical polarization inside the film, and eventually increasing the device capacitance. On the other hand, the PCS<sub>x</sub> molecules are negatively charged providing favorable sites for hole transport. Both mechanisms contribute to the lowering of the operating voltages and to higher channel currents. In order to clarify this displacement of ions,  $I_d$  vs time was recorded after applying a gate voltage at  $t=0$ .