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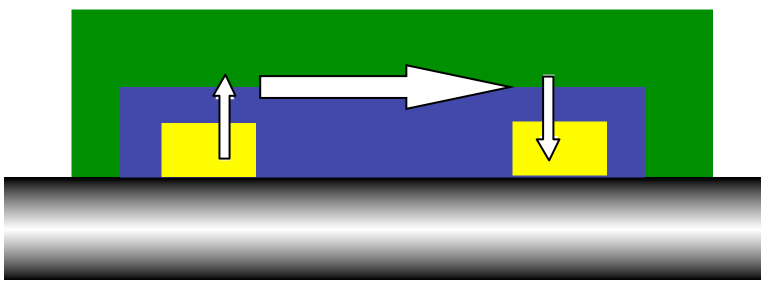
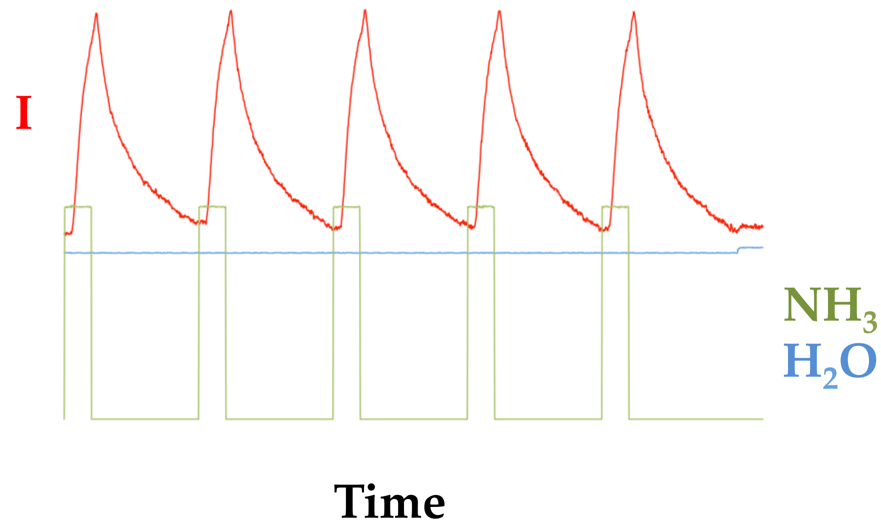
Molecular Semiconductors — Doped Insulator (MSDI) heterojunctions as new conductometric devices for chemosensing in wet atmosphere





Summary

Introduction

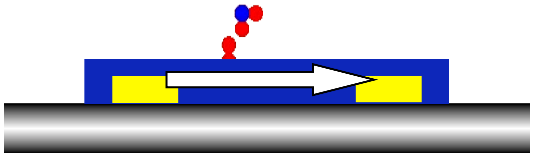
Molecular Semi-conductor — Doped insulator heterojunctions (MSDI)

Sensors response

Conclusion

INTRODUCTION

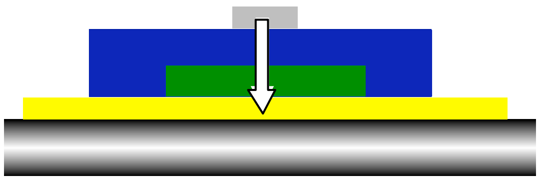
Conductometric Transducers



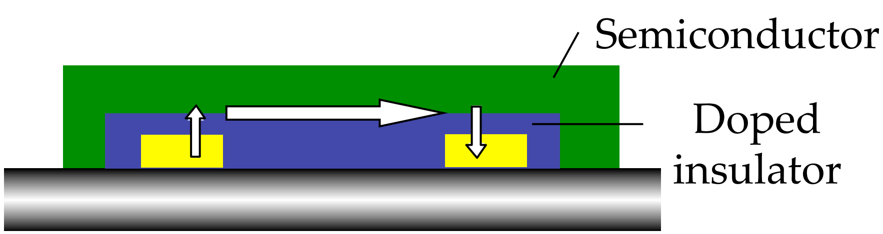
Resistor

Conductivity : $\sigma = n \; e \; \mu$ $\Delta[G] \Rightarrow \Delta n \Rightarrow \Delta\sigma \Rightarrow \Delta I$

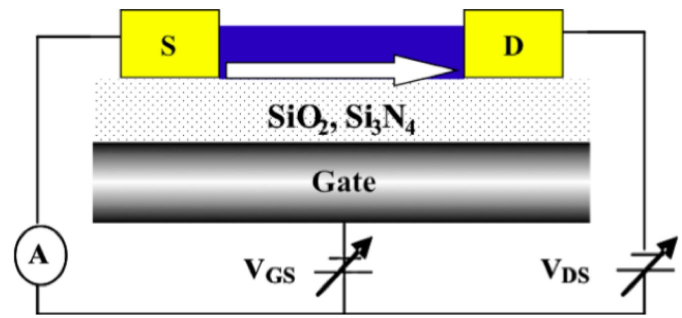
Variation of n (doping effect or neutralization) or mobility (effect on transport properties)



Diode



MSDI



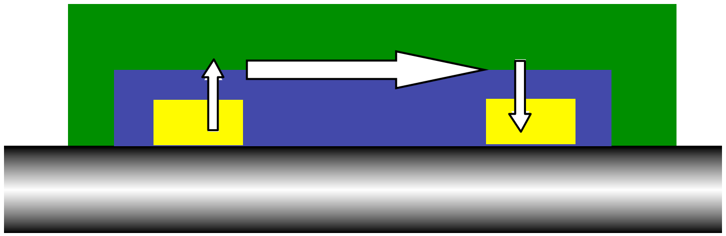
Transistor

M. Bouvet, "Phthalocyanine - based field-effect transistors as gas sensors", Anal. Bioanal. Chem., 384, 366-373, **2006**.

I. Muzikante et al. "A novel gas sensor transducer based on phthalocyanine heterojunction devices", Sensors, 7, 2984-2996, **2007**.

V. Parra et al. "Molecular semiconductor - doped insulator (MSDI) heterojunctions, an alternative transducer for gas chemosensing", Analyst, 134, 1776-1778, **2009**.

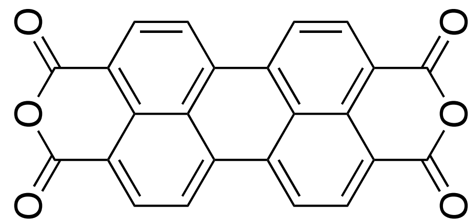
Molecular materials used in MSDIs



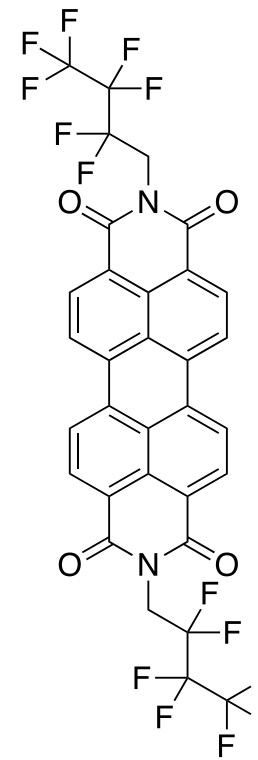
MSDI

Sub layer => n type

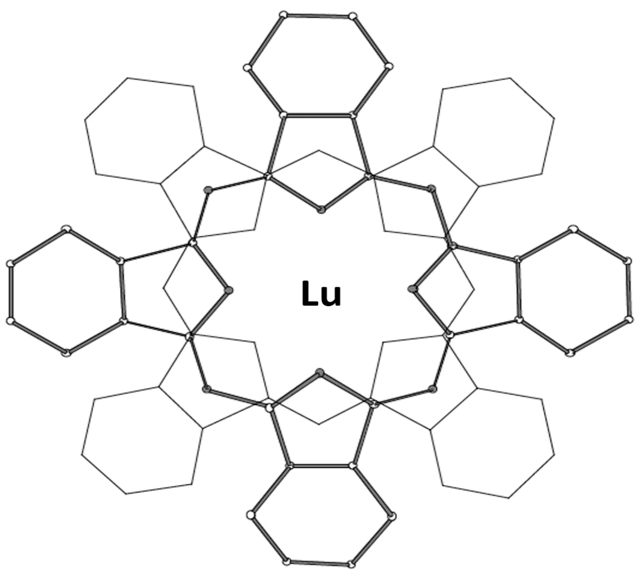
PTCDA



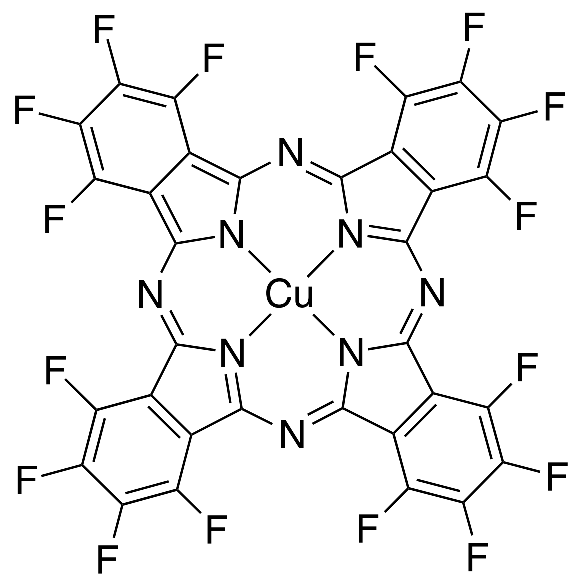
C_4F_7-PTCDI



Top layer => p type

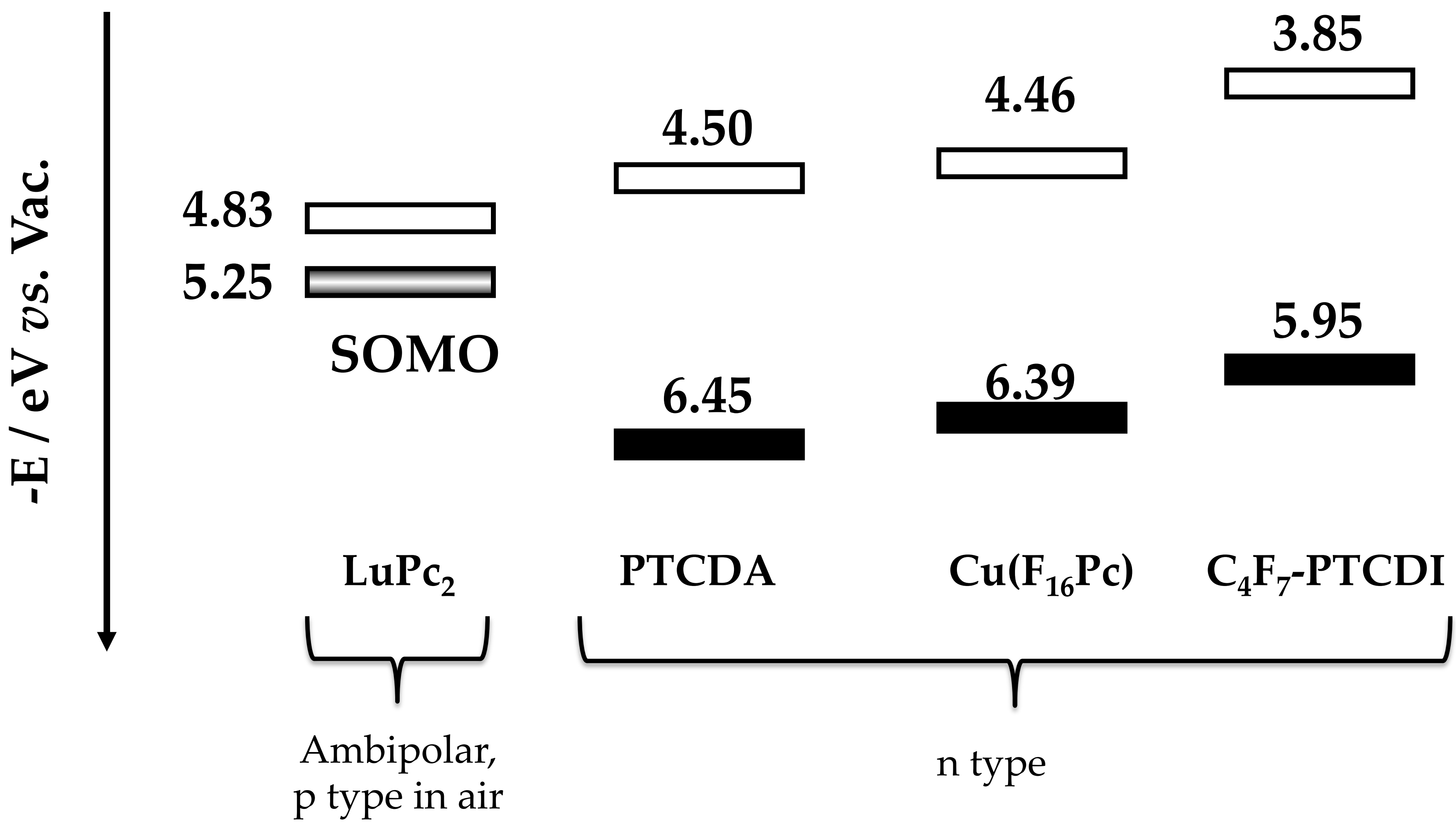


$LuPc_2$



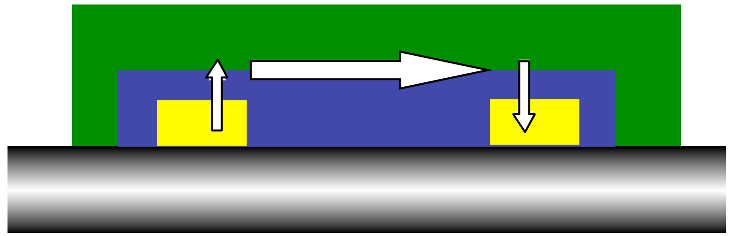
$Cu(F_{16}Pc)$

Energy levels of molecular materials

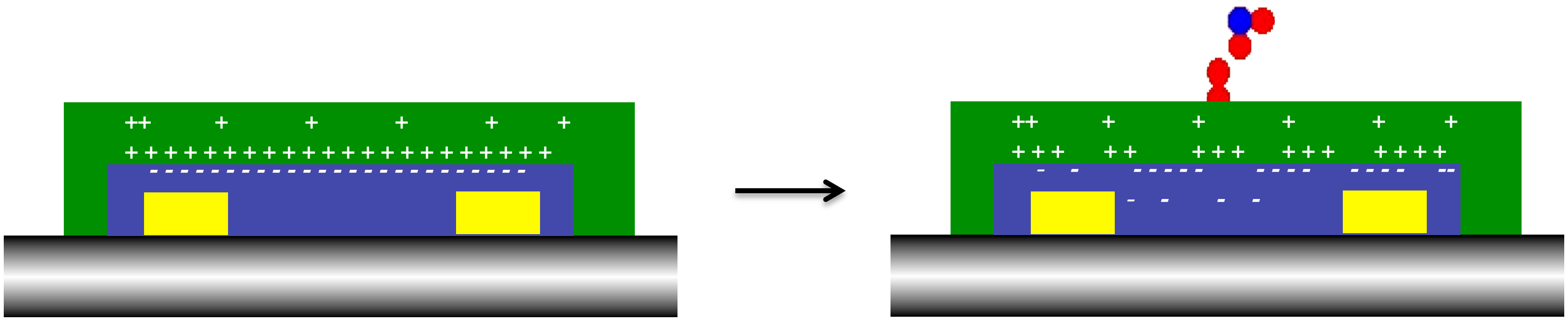


Molecular Semiconductor — Doped-Insulator heterojunctions (MSDI)

➢ Molecular Semiconductor — Doped-Insulator heterojunctions (MSDI)



The conduction path of charge carriers



Distribution of charge at the interface before adsorption of gas

Distribution of charge at the interface after adsorption of gas

Adsorption of $NH_3 \Rightarrow \searrow$ p in $LuPc_2 \Rightarrow \nearrow$ I

Sensors response for MSDI

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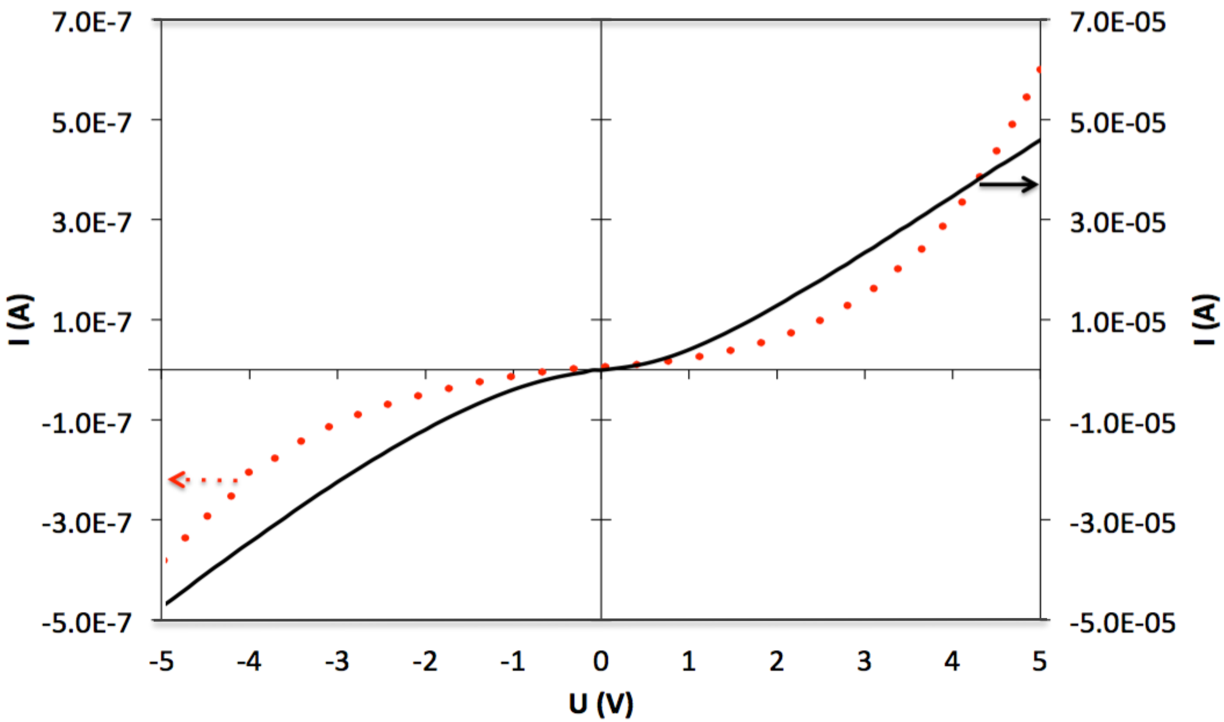
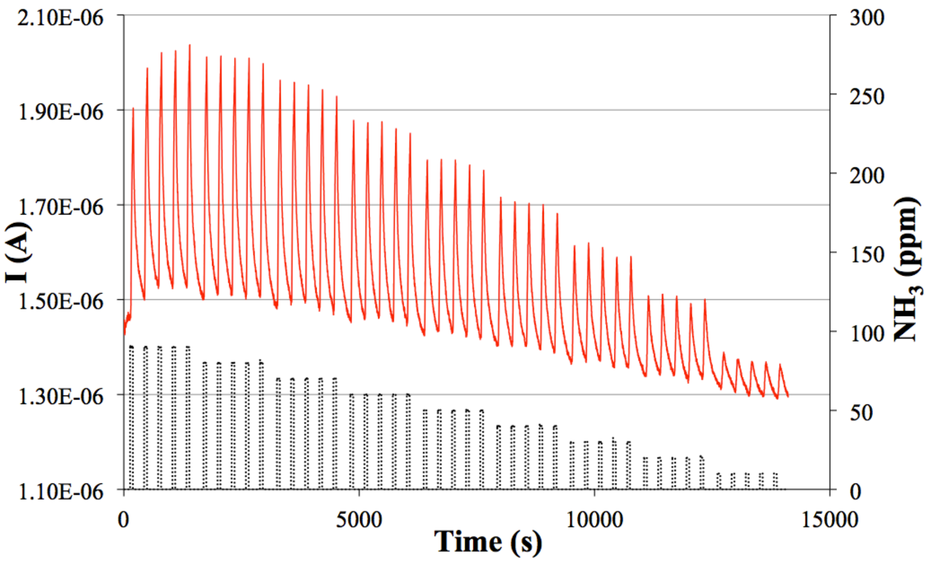
I(U) characteristics of PTCDA $LuPc_2$ and C_4F_7-PTCDI (50 nm)/$LuPc_2$ (50 nm)

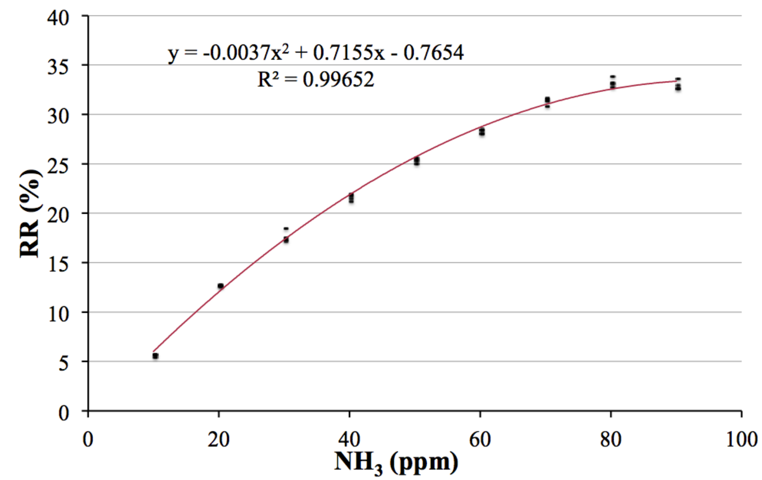


PTCDA/$LuPc_2$ 30/70 sample (solid line) and a C_4F_7-PTCDI/$LuPc_2$ 50/50 film (dotted line)

The plateau of C_4F_7-PTCDI is due to the energy barrier more important than in PTCDA

Response to ammonia at 50 % rh of C_4F_7-PTCDI (50 nm)/$LuPc_2$ (50 nm)

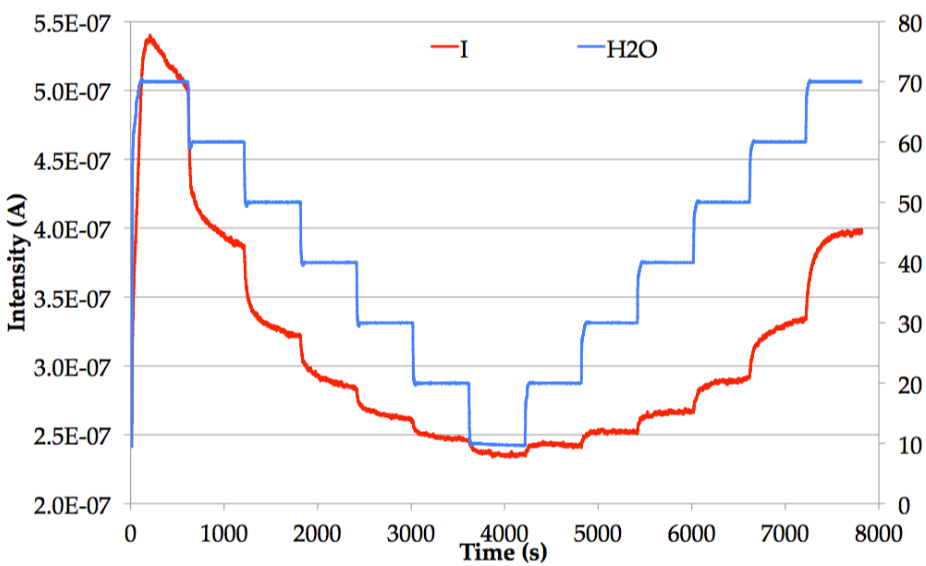


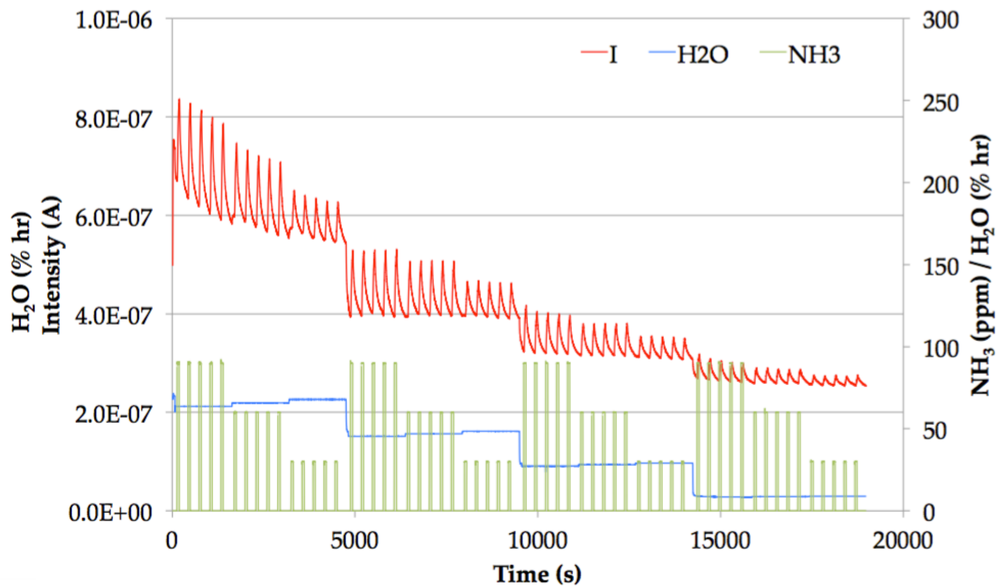


Our sensor answers at many concentration of NH_3 from 10 ppm to 90 ppm.
We observed a weak sensitivity to relative humidity (rh) variation of the response to NH_3

➢ Sensors response for MSDI

Response to ammonia at different rh and NH_3 rate of C_4F_7-PTCDI (50 nm)/$LuPc_2$ (50 nm)

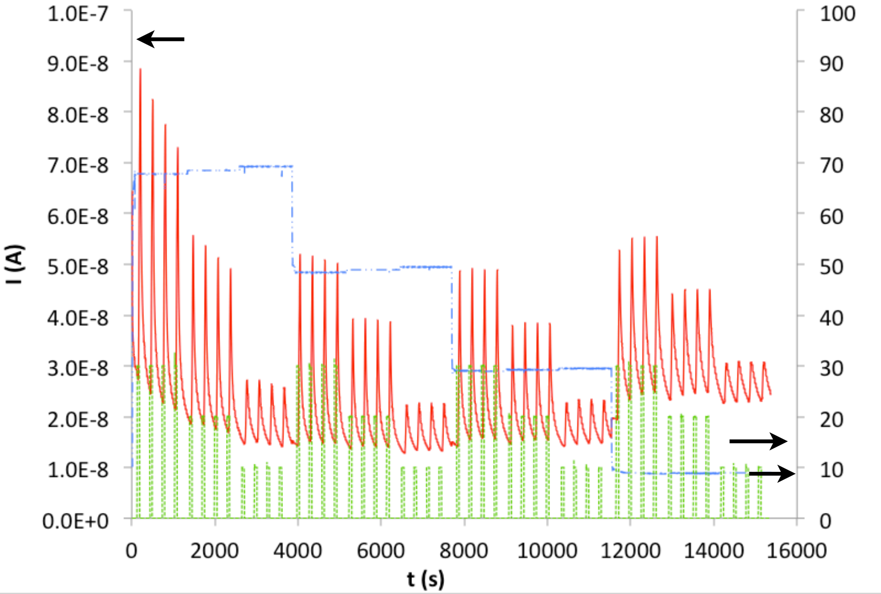


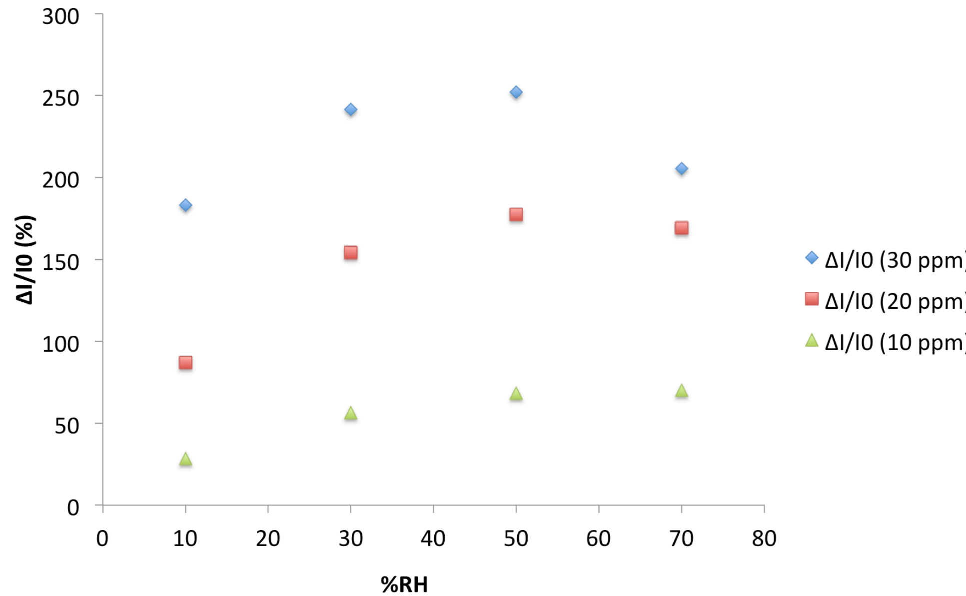


Left: we exposed this sensor at 70 % -> 10 % -> 70 % relative humidity.
Under 40 % rh this sensor isn't sensible to humidity.
The difference between the beginning of the experiment and the end is due to the desorption speed of H_2O molecules.
Right: we exposed to ammonia from 90 to 30 ppm, under synthetic air loaded with 70–10% rh .
The exposure to ammonia shows a drift of base line at high level of water (70 % rh).

➢ Sensors response for MSDI

Response to ammonia at different rh and NH_3 rate of PTCDA (50 nm)/LuPc$_2$ (50 nm)





Left : :we exposed to ammonia from 30 to 10 ppm, under synthetic air loaded with 70–10% rh.
Right : with this representation of relative humidity we can see that it is possible to determine the NH3 concentration if we know the relative humidity if we don't consider 10 % rh (it is rarely reel world).
This sensor discriminate ammonia.

Conclusion

➢ Conclusion

PTCDA/$LuPc_2$

- A high sensitivity to ammonia with a good reversibility
- Good discrimination between the ammonia concentrations (better than 10 ppm) was observed in a broad range of relative humidity

C_4F_7-PTCDI/$LuPc_2$

- Not affected by humidity

✓ **the interest of MSDIs as chemical sensors operating in real-world atmospheres, moreover at room temperature.**

Acknowledgments

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European Network on New Sensing Technologies
for Air-Pollution Control and Environmental Sustainability

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