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XXXIV Cycle

# Development of polymeric materials as flexible chemiresistive gas sensors


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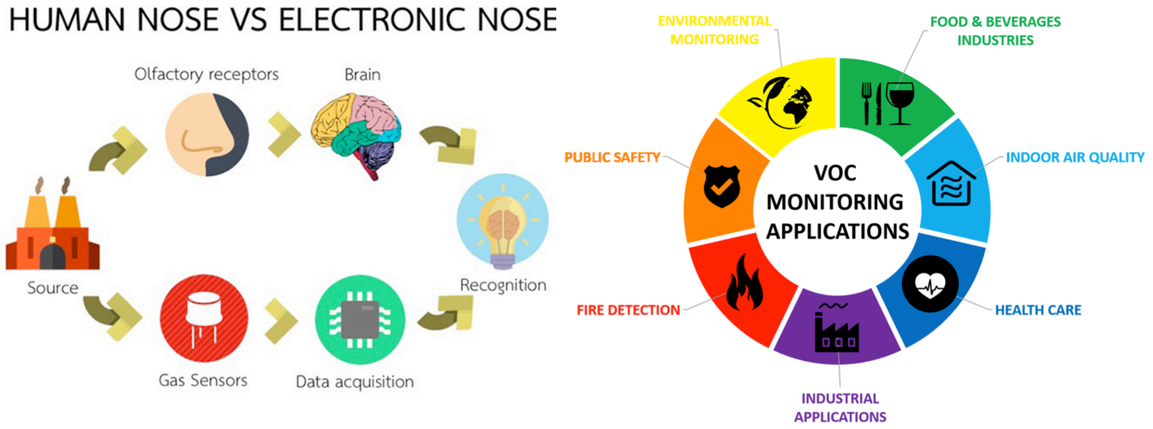
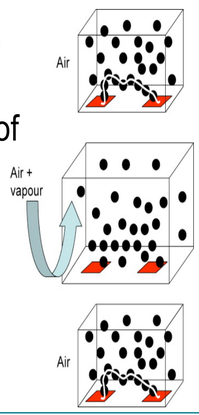
## Research context and motivation

- The development of miniature and portable gas sensors able to detect gaseous analytes in real time with good sensing performances will significantly change our daily life.
- In the scientific literature there is a large interest for these sensors where the improvement of sensitivity and selectivity is required.
- Metal oxide semiconductors, conducting polymers, and composites are among the most common active materials employed for the manufacturing of these devices.

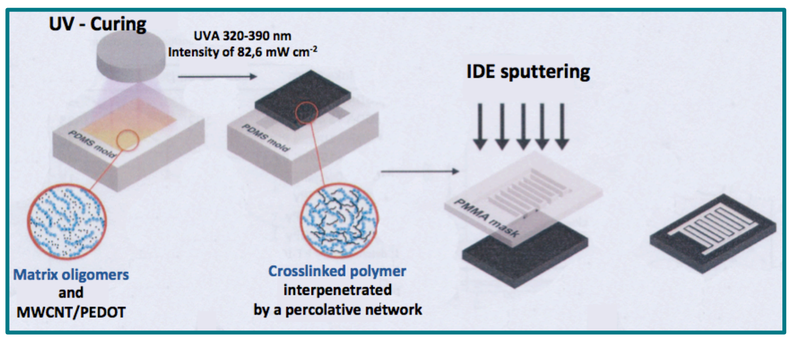



- They are called chemiresistor sensors because the transduction mechanism involves the adsorption of the gas on the sensor surface with a consequent clear electric resistance variation, which is usually appreciated as a change of output current.
- Among chemiresistive gas sensors, polymer composites are the best choice when flexibility is required. Furthermore, they have several unique attractive features such as versatility, lightweight, low energy consumption and operational temperature, low cost, and the potential to be adapted for many different applications.

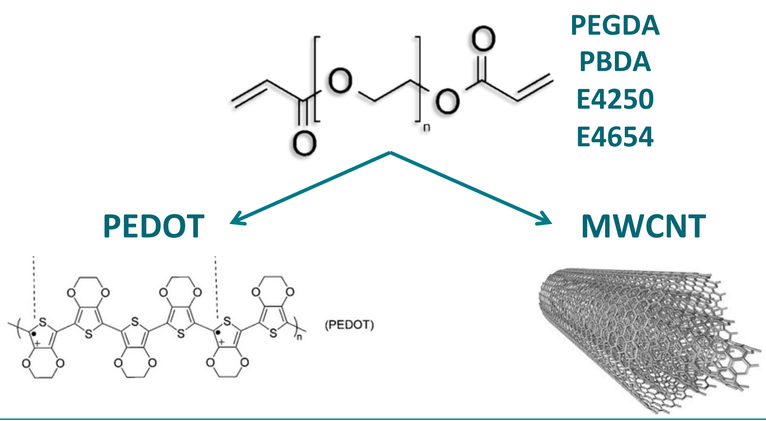



## Addressed research questions/problems

- The aim of the research activity is the fabrication of simple and more efficient polymeric responsive vapor sensors with the goal of optimizing the “3S”: sensitivity, selectivity and stability.
- The UV curable formulations used are a blend of monomers, oligomers and a photoinitiator (PI) activated by UV light (320-390 nm).




- Poly (ethylene glycol) diacrylate (PEGDA), polybutiadene diacrylate (PBDA), Ebecryl 4654 and Ebecryl 4250 are used as matrix, searching different affinities toward different gases based on polarity. The acrylic groups allow the crosslinking of the material. In order to enhance the electrical conductivity of the mixture, conductive fillers are used: multi-walled carbon nanotubes (MWCNTs) and poly (3,4-ethylene dioxy thiophene) (PEDOT).

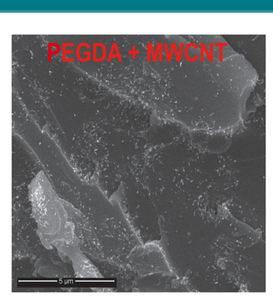


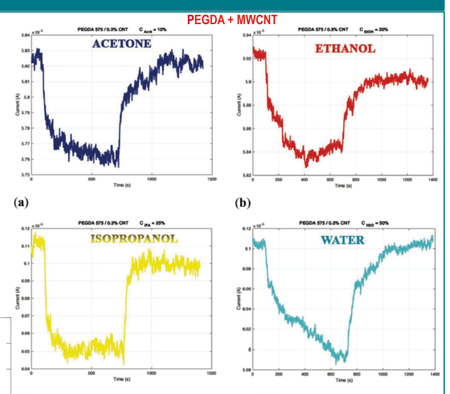

## Submitted and published works

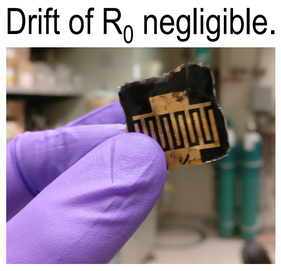

- Vigna, L., Fasoli, A., Cocuzza, M., Pirri, C.F., Bozano, L.D., Sangermano, M., “*A Flexible, Highly Sensitive, and Selective Chemiresistive Gas Sensor Obtained by In Situ Photopolymerization of an Acrylic Resin in the Presence of MWCNTs*”, Macromol. Mater. Eng., vol. 304, no. 2, 2019, p. 1800453

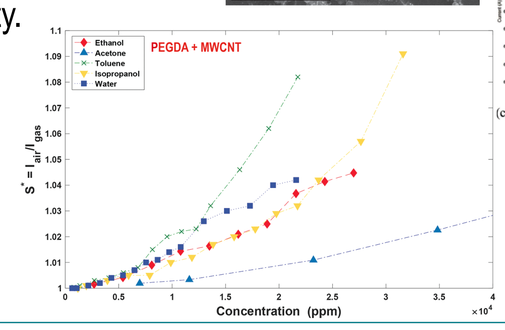

## Novel contributions

- Certain degree of selectivity toward different gases.
- Swelling behavior.
- Homogeneous dispersion of CNTs is evident in the FESEM image.
- R in the range of kΩ.
- Influenced by humidity.
- Drift of $R_0$ negligible.



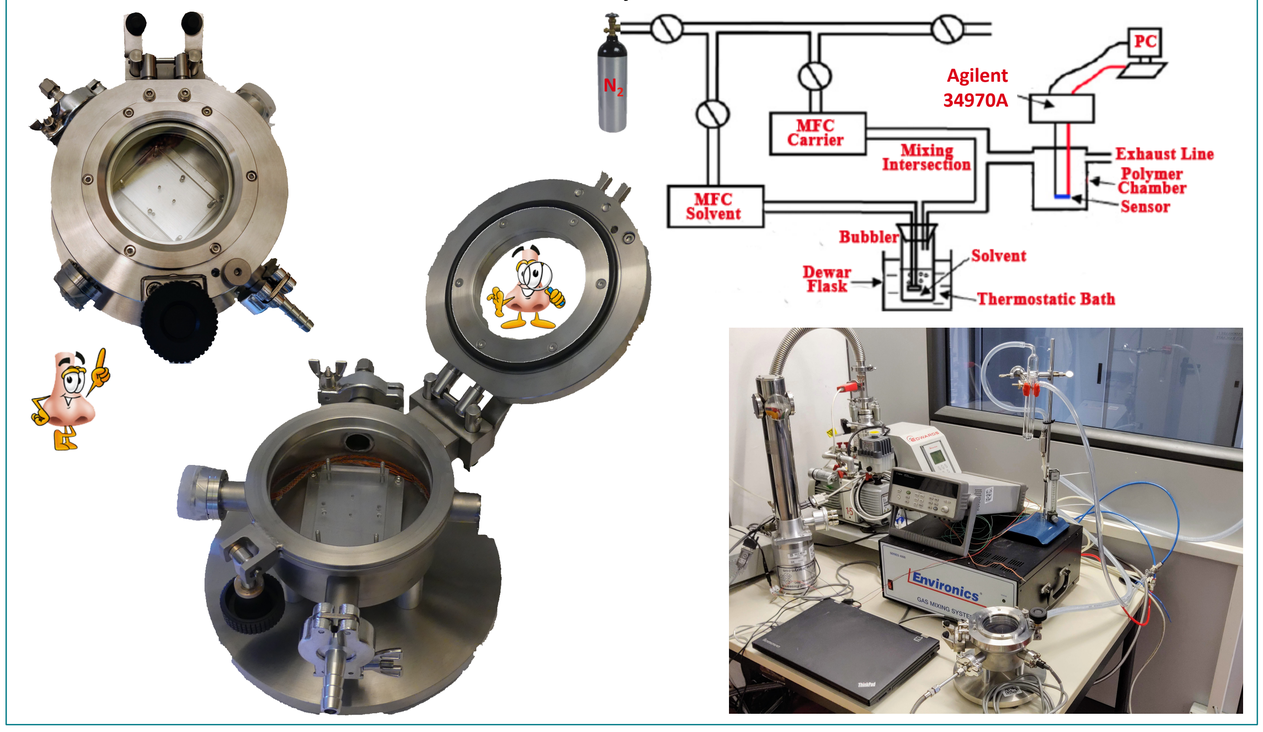






## Adopted methodologies

- The sensing characterizations are carried out by using a custom-made sensing setup in order to produce and deliver selected concentrations of solvent vapors to the samples.
- In the system, a stream of pure nitrogen is exploited as carrier and diluting gas. The main stream is divided into two fluxes regulated by the presence of two mass flow controllers (MFC). The carrier gas flows through a thermostatic chamber composed of a bubbler evaporation system properly filled with the volatile organic compound (VOC) to be tested. Past the bubbler, the two flows are recombined, mixed, and directed to a detection chamber made of a stainless steel assembly.




## Future work

- Measurements standardization with the Gas Sensing Chamber and repeatability of the tests.
- Improvements and modification of the photocurable mixture, modifying the chemistry of the resin and therefore the affinity toward polar and non-polar gases.
- Enhancement of the electrical conductivity of composites with PEDOT and CNT.
- Optimization of the “3S”: sensitivity, selectivity and stability.
- Fabrication of a sensors array: the Electronic Nose

## List of attended classes

- 01SDDKI – Additive Manufacturing Polimerico (19/07/2019, 4 CFU)
- 01SZPKG – Introduzione alla Microscopia Elettronica (16/09/2019, 4 CFU)
- 01LXBRW – Life Cycle Assessment LCA (05/07/2019, 5 CFU)
- 01TANRO – Ocean Energy (24/09/2019, 2 CFU)
- 01TGTKI – Physical Chemistry of Materials for Nanotechnologies (19/06/2019, 7 CFU)
- 01MOVKI – Polimeri e Radiazioni (17/04/2019, 5 CFU)
- 01QSXRU – The Measurement of Electrical Impedance (05/03/2019, 2 CFU)
- 01QORRV – Writing Scientific Papers in English (21/02/2019, 3 CFU)

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