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Gas Sensors Based on Organic-Inorganic Hybrid Nanostructures: the porphyrins – ZnO case

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The large versatility of organic chemistry allows for the preparation of countless materials of different affinity and selectivity respect to volatile compounds. The sensitivity of these materials is generally based on sorption mechanisms and the sensitive materials can be synthesized in order to modulate the intensity of a number of different interactions such as Van der Waals forces, hydrogen bonds, CH-π, π-π interactions, and coordination bonds.
In this talk, the particular case of porphyrins is discussed. Porphyrins are well-known molecules that play fundamental roles in living systems, such as the oxygen activation and transport and electron transfer in animals and the photosynthesis in plants. These characteristics are widely studied to mimic them in artificial systems. They are also interesting for chemical sensing, since porphyrins are among the most versatile ligand platforms, forming a wide range of metal complexes; they can interact with airborne molecules by a wide spectrum of different mechanisms. The large π-electron aromatic system allows porphyrins to act as both electron donors and acceptors. These properties have been exploited to design several sensors for the detection of chemical in both gas and liquid phase [1].
Besides these intrinsic molecular properties, the porphyrin grafting onto inorganic surfaces, such as ZnO nanoparticles, can bring additional modulation of the overall sensors performance. In these systems, the contribution of the spatial arrangement to the overall selectivity can be so large to make possible to form a sensor arrays even with a single porphyrin but grafted on different nanostructures, and to preserve enantioselectivity that otherwise disappear in compact films [2].
In these hybrid materials, the interplay of light and gas sensitivity plays introduces an additional source of sensitivity to volatile compounds. The nanorods can be conveniently coated by porphyrins, exploiting the binding properties of a carboxyl functional group. The porphyrin functionalization results in a uniform coverage of both the top and the lateral surfaces of the nanorods. The illumination with visible light improves the electric conductivity to electron donor species (e.g. amines). This approach has been further explore with nanoparticles. Although the largest sensitivity is observed towards electron donors, the sensitivity to other molecular families is not negligible and the combinatorial selectivity can still be exploited also with porphyrins based resistive sensors [3].

References

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