Sensing Molecules and Temperature at the Nanoscale

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In this talk I shall review some of the work carried out in Aveiro in the last 6 years, or so, on the design, synthesis and characterisation of lanthanide (Ln) -bearing nanostructures for sensing small molecules and temperature. Selected examples of (i) nanoporous metal-organic frameworks and silicates, and (ii) gold and Ln oxides nanoparticles systems will be given.

Nanoporous metal-organic frameworks (MOFs) are crystalline materials consisting of metal ions bridged by organic linkers and exhibiting porosity reminiscent of zeolites. Ln^{3+}-organic frameworks are very promising materials for tackling the challenges in engineering of luminescent centres, also presenting much potential as multifunctional systems, combining light emission with properties such as microporosity, magnetism, chirality, molecule and ion sensing, catalysis and activity as multimodal imaging contrast agents [1]. Only 10% or so of MOFs are effectively nanoporous, exhibiting zeolite-type behaviour, and photoluminescent. The combination of porosity and light emission allows the design of intriguing new types of chemical species and temperature sensors, which I shall highlight here [2-6].

In general, the thermal stability of MOFs is limited and materials such as silicates present interesting alternatives for certain applications. We have recently reported a new Ln silicate orthorhombic system, $Na[(Gd_{1-a}Eu_a)SiO_4]$, exhibiting uncommon photoluminescence properties due to structural disorder and a phase transition. This system constitutes the first example of a ratiometric thermometer based on a Ln^{3+} silicate, particularly sensitive at cryogenic temperatures (<100 K) [7].

While the use of plasmonic nanoparticles as sources of heat have attracted much interest in the last decade, research into ratiometric nanothermometers with high-spatial resolution is comparatively new. Suitable nanoplatforms integrating heaters and thermometers, however, have not been realized, despite their great potential in nanophotonics and biomedicine. In this talk I shall report a step forward towards assessing the local temperature of laser-excited gold nanostructures using an all-in-one nanoplatform comprising $(Gd,Yb,Er)_2O_3$ nanorods (thermometers, NR) that were surface-decorated with gold nanoparticles (heaters, AuNPs) [8].

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