CARBON DOTS (CDs) LUMINESCENCE: A TOOL FOR DESIGNING NEW MATERIALS

Carbon Dots (CDs) are luminescent nanoparticles discovered in 2004. **They have the advantage of avoiding the use of metals, sometimes rare, in the design of luminescent materials**. This generic name gathers carbon nanoparticles with sizes below 10nm. Numerous studies arose these past few years owing to the extreme simplicity of the synthetic routes (hydrothermal, microwaves…) and the wide range of molecular precursors able to lead to CDs. Our group studies these nanoparticles having different goals in mind.

While the development of sensors for ion detection was first successfully investigated for the specific detection of mercury[1], other more promising applications are now investigated. We first focused our work on hydrophobic nitrogen-doped CDs emitting in the red light range, i.e. Red Dots. These Red Dots have the particularity of being able to be excited both in the UV range (300-375nm) and in the blue-green light range (450-600nm) (**Fig. 1-b**). According to the literature, the doping of the CDs graphitic core with certain elements (N, S, ...) or the presence of functional groups on the surface can explain this dual excitation. However, the mechanisms are not clearly identified and we recently started to collaborate with modellers capable of simulating the emission spectra of CDs based on their structural design.

This dual excitation allows us to envisage two types of promising applications: β scintillators[2] and LEDs[3]. In the case of β scintillators, the Red Dots are dispersed in a plastic matrix (Polystyrene, PS) sensitive to β^- radiation (electrons) (**Fig 1-c**). The PS emits UV light when exposed to β radiation, thus activating the red emission of the Red Dots by a radiative energy transfer mechanism (**Fig 1-d**). This subject is the topic of Rayan Roch's thesis, which will be defended in 2024.

In the case of LEDs, the blue excitation property of red dots is used. The most widespread LEDs technology uses an InGaN semiconductor chip that emits in the blue because it is the most energy efficient. The blue light is then converted by a layer of phosphor to produce another richness of light at different wavelengths (white light, red light etc.). Our team is developing phosphors based on Red Dots that can convert part of the blue light into red light and thus produce a pink/purple light that is very useful in the horticultural field for boosting plant growth (**Fig 1-e to h**). Horticultural lamps represent a growing market due to the development of vertical farms which aim to reduce the food supply circuits in large urban centres (Plenty, Aerofarms, Jungle etc...). This subject is being addressed at the LNER through a start-up project via the CEA's Magellan program. The **Excidots** project has already established partnerships with local companies (VGD Led) and has established contacts with international companies (OSRAM).

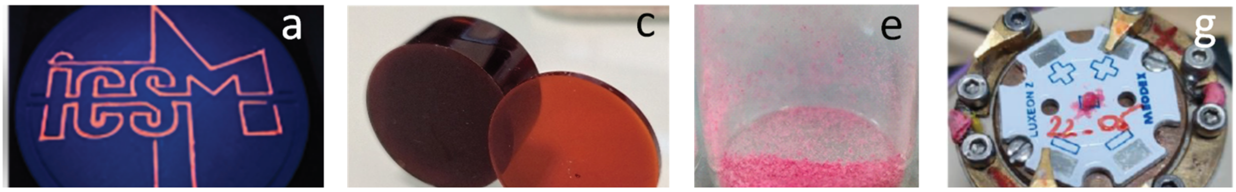

*Figure 1. **a-** ICSM logo made of Red Dots under UV excitation @ 365nm. **b-** Contour 2D diagram showing dual excitation of Red Dots for a single emission in the red region (650nm). **c-** Plastic scintillators made with Red Dots under artificial white light. **d-** Red Dots scintillators under ^{90}Sr (β^-@0.5MeV) source excitation. White pixels show visible emission. **e-** Red Dots phosphors. **f-** Scheme of the operating principle of a LED with Excidots phosphors. **g-** LED with an Excidots phosphor layer. **h-** Production of pink/purple light with a LED equipped with an Excidots phosphor layer.*

[1] C.M. Singaravelu, X. Deschanels, C. Rey, J. Causse, **Solid-State Fluorescent Carbon Dots for Fluorimetric Sensing of Hg2+**, ACS Applied Nano Materials. 4 (2021) 6386–6397

[2] J. Causse, C.M. Singaravelu, C. Mahe, C. Lepeytre, M. Hamel, **Matériau scintillateur et procédé de fabrication**, 2022, patent FD22039

[3] J. Causse, C.M. Singaravelu, **Procédé de conversion lumineuse et dispositif émetteur de lumière**, 2022, patent FD22816