Post-doc fellowship

New synthesis strategies for controlling and improving the understanding of the fluorescence properties of carbon dots

(duration: 18 months)

Since their discovery in 2004, carbon dots (CDs) are the focus of growing interest. Indeed, these zero-dimensional carbon-based nanomaterials have revolutionized the paradigm of carbon which, as a "black" material, is incapable of emitting light. In particular, CDs display a very bright fluorescence with no equivalent in other nanocarbon materials families. Therefore, they appear as very promising nanomaterials because they offer the same perspectives as optically-active semiconductor quantum dots (QDs) with additional benefits of a metal-free carbon-based material. They combine also several additional interesting properties (low-cost, high water solubility, non-toxicity, bio and eco-compatibility, chemical and optical stability…) making them particularly promising for many applications (optoelectronic devices, bioimaging, biological and chemical sensing, catalysis, and so on). As a consequence, CDs appear nowadays as a rising star in nano-science. While this carbon nanoparticles family provides a versatile platform to build a huge variety of light-related applications, their development to a widespread use may be very rewarding for current and future technologies.

However, we are still very far from fully exploiting the potential of CDs. Despite their promising performances, their current understanding is still insufficient for commercial applications. The literature is fragmented and many studies are the result of a heuristic approach. In particular, their synthesis is still poorly understood, and many protocols raise questions. For example, several recent studies have highlighted the formation of fluorescent organic molecules during the CDs synthesis, making it difficult to attribute their optical properties to the sole contribution of CDs. The fluorescence mechanism is also still highly debated in literature. The presence of doping atoms and surface functional groups seem to have a role, although it is not yet well established.

This project aims to acquire better knowledge on the physicochemical properties, and in particular optical properties, of CDs, by highlighting the relationships between structure and properties. Does the size of CDs influence their fluorescence properties? What is the role of surface groups on the fluorescence of CDs? How does their fluorescence evolve in the presence of dopants like heteroatoms? Such fundamental studies on the fluorescence properties of CDs have indeed never been reported in the literature.

We will initially focus on developing new strategies for the synthesis of CDs, via a top-down approach, in particular by electrochemical method or by laser ablation (in collaboration with ENS Paris Saclay). The parameters and precursors used during theses syntheses will be modulated in order to vary and control the CDs obtained, which will then be characterized by different techniques (TEM, XPS, Raman and IR spectroscopies…) and whose fluorescence properties will be studied.

In a second step, we will explore the possibility of modulating post-synthesis the fluorescence properties of these CDs, in particular by functionalizing them. In particular, we will consider the influence of electron-withdrawing groups *vs.* electron donor groups, π-conjugated groups *vs.* saturated groups… on their fluorescence properties.

Finally, their functionalization with materials presenting switchable physicochemical properties (conductive polymers, thermoresponsive polymers, photoisomerisable azobenzene derivatives…) could also be studied with the aim of reversibly modulating the CDs fluorescence under the action of an external stimulus.

Contact: **Dr. Delphine Schaming** (delphine.schaming@u-paris.fr)