Harnessing Sustainable Nanomaterials: Empowering Biosensing and Environmental Innovations

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Abstract

In recent years, carbon dots, a relatively new class of nanomaterials, have come to light.[1] Carbon dots are carbon, oxygen, nitrogen and hydrogen containing materials with the first two elements typically accounting for ~80% of their elemental composition. Moreover, they are typically water dispersible and can be prepared from an abundant number of inexpensive sources including small molecules such as citric acid, amino acids and sugars. While they are small in size (typically 1-10 nm), they can offer a high quantum yield of emission, a process that is controlled through passivation of the surface with an organic reagent. Of particular interest are their optical properties, which can be tailored via careful selection of the starting precursors and the desired synthesis route resulting in the ability to generate fluorescence from the blue to the near infrared regions of the spectrum (Figure 1).

Fig. 1. The fluorescence of the carbon dots can be tuned from the blue to the far red/near-infrared regions of the spectrum.

Their versatile optical properties and the development of dual fluorescent systems allow us to develop ratiometric optical based sensing probes that can be used in biological systems focusing on temperature and pH sensing of physiological events in live biological model systems.[2,3]

More recently, we have also exploited the optical properties for environmental sensing applications focusing on and emerging contaminants such as pesticides and emerging organic pollutants. Recent efforts focused on sensing for glyphosate in water. Using these carbon-based nanomaterials, we are able to achieve ppb detection levels. More recently, we have focused our work on the preparation of biomass derived environmental decontamination agents with a focus on capture, recovery and reuse. Our findings suggest that it is possible to positively contribute to environmental remediation efforts in an efficient and cost-effective manner that can be applied on a global scale.

Recent Publications (maximum 5)

1. de Medeiros, T. V.; Manioudakis, J.; Noun, F.; Macairan, J.-R.; Victoria, F.; Naccache, R. *J. Mater. Chem. C.* 7 (2019) 7175-7195.
2. Macairan J. R., Jaunky D. B., Piekny A. and Naccache R. *Nanoscale Adv.* 1 (2019) 105-113.
3. Macairan J. R., Zhang I., Clermont-Paquette A., Naccache R. and Maysinger D. *Part Part Syst Charact.* 7 (2019) 1900430.
4. de Medeiros T., Macina A. and Naccache R. *Nano Energy* 78 (2020) 105306.
5. Claremont-Paquette A., Mendoza D. A., Sadeghi A., Piekny A. and Naccache R (2023) 5200.

Biography

Rafik Naccache obtained his PhD (2012) in Chemistry at Concordia University in Quebec, Canada working on lanthanide-doped upconverting nanoparticles for imaging applications. There, he was the recipient of the Distinguished Doctoral Dissertation Prize and the Governor General Gold Medal in the area of Technology, Industry, and the Environment. He subsequently carried out his NSERC postdoctoral training in nanobiophotonics at l'Institut National de la Recherche Scientifique developing Terahertz sensing applications in nanobiophotonics. In December 2015, he accepted a tenure track faculty position as a strategic hire in the Department of Chemistry and Biochemistry at Concordia University. He is currently an Associate Professor, the Director of the Centre for NanoScience Research and a University Research Chair. His group's research focuses on the study of the fundamental properties of fluorescent carbon nanomaterials and hybrid nanosystems for the development of sensing, imaging and catalysis applications. He has published over 70 manuscripts and has an *h*-index of 37 with nearly 8000 citations. Email: rafik.naccache@concordia.ca