

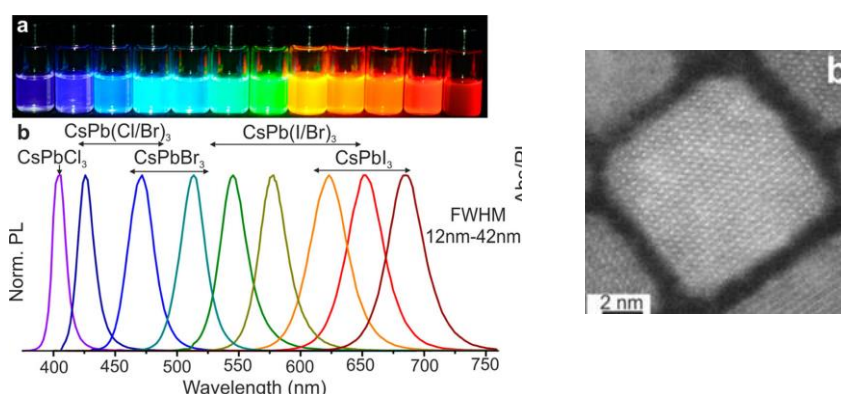
## 14: Chemical synthesis of perovskite nanocrystals, their microscopic and spectroscopic characterization

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Colloidal nanocrystals (NCs) are small, soluble crystals, which comprise a few hundred to several thousands of atoms. They are prepared by interrupting the crystal growth at a very early stage and can be synthesized for a wide variety of materials, ranging from semiconductors to metals to oxides. Colloidal NCs are usually synthesized by thermal decomposition of precursors in hot coordinating solvents. They are dispersed in solution and can be produced in large quantities, they are versatile and robust enough to be manipulated after the synthesis step for their integration with existing technologies.<sup>1,2</sup> Two major reasons are at the basis of the peculiarity of nanocrystals: the significant fraction of atoms at the surface, as compared to that found in the corresponding bulk counterparts, and the restriction of charge carrier motion to a small material volume. Metal halide perovskite nanocrystals (HPNCs) are a newly emerging research field, with the very first paper dating from 2014. Initially, organic-inorganic hybrid perovskite NCs such as methylammonium lead bromide (MAPbBr<sub>3</sub>) were developed fueled by the very successful incorporation of these semiconductors in the bulk form as light harvesters in solar cells. Later, fully inorganic HPNCs such as CsPbBr<sub>3</sub> have first been reported by Kovalenko et al.<sup>3</sup> The most intriguing feature of HPNCs is their very strong photoluminescence reaching quantum yields close to unity with no necessity for surface passivation other than by pristine ligand coverage. Another striking feature distinguishing them from other NCs is that color tuning is most easily achieved not by size variation but via solution phase anion exchange, with a reduction of the band gap energy in the order Cl > Br > I (Fig. 1). Due to their versatility, colloidal HPNCs offer a wide spectrum of possible applications, such as fabrication of photovoltaic devices, LEDs, lasers etc.

To obtain high quality nanoparticles with competitive physical and chemical features, the synthesis approach by means of wet chemistry methods is often proffered. In a typical synthesis of HPNCs, inorganic or organometallic precursors are injected in a mixture of surfactants that are held at a temperature sufficient to cause thermal decomposition of the precursors and hence to induce homogeneous nucleation of nanoparticles.

The aim of this practical work is to synthesize CsPbBr<sub>3</sub> and CsPbI<sub>3</sub> nanoparticles and to measure their optical properties (½ day), then to image them by Scanning transmission electron microscopy (STEM and EDX) techniques (½ day). It will be based at the Institute of Nanosciences and Cryogenics (INAC) at CEA Grenoble. Studies level requested to follow this practical: Master of Science in Chemistry or Material's Science.



**Figure 1:** a) b) Composition-dependent change emission colour for colloidal solution of CsPbX<sub>3</sub> HPNCs. b) STEM image of cubic CsPbBr<sub>3</sub> NCs.

<sup>1</sup> Aldakov, D.; Reiss, P. J. *Phys. Chem. C*, 2019, DOI: 10.1021/acs.jpcc.8b12228

<sup>2</sup> <http://inac.cea.fr/spram/NanoX/publications.htm>

<sup>3</sup> Protesescu, L.; Yakunin, S.; Bodnarchuk, M. I.; Krieg, F.; Caputo, R.; Hendon, C. H.; Yang, R. X.; Walsh, A.; Kovalenko, M. V. *Nano Lett.* **2015**, *15*, 3692-3696.