Continuous flow aqueous synthesis of luminescent $AgInS_2$ nanocrystals and optical characterization

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Over the past four decades quantum dots (QDs) have attracted much attention due to their unique electronic and optical properties due to their small size (d< 10nm). Most research has focused on QDs with binary composition, i.e., composed of II-VI and IV-VI semiconductors, such as CdSe, CdTe and PbS, due to their size-tunable light emission, broad absorption spectrum and long-term photostability. Unfortunately, these nanomaterials contain toxic elements, so major efforts are currently devoted to the development of safer and more environmentally friendly QDs. This evolution has led to a growing interest in ternary chalcopyrite QDs of composition I-III-VI_2 (I: Cu, Ag; III: In, Al, Ga, Bi; VI: S, Se, Te) with the most common in recent literature being $CuInS_2$ (CIS) and $AgInS_2$ (AIS). Colloidal syntheses of ternary I-III-VI QDs are most often performed in organic solvents, and therefore, the obtained QDs cannot be directly applied in biological studies or in photocatalytic reactions taking place in water. Phase transfer from an organic to an aqueous medium involves additional steps and is often associated with a significant decrease in photoluminescence quantum yield (PLQY) and colloidal stability. An interesting alternative has been developed: direct aqueous phase synthesis.

Despite many optimizations, several intrinsic problems cannot be solved by conventional batch synthesis techniques. In particular, the QD quality in terms of PL peak position, line width and PLQY, can vary from batch to batch due to subtle changes in experimental parameters, making it difficult to ensure consistency and reproducibility. Continuous flow chemistry has recently emerged as a promising approach for the synthesis of high-quality colloidal QDs. It offers the potential to produce QDs with better size control and reproducibility due to the more precise control of the reaction conditions (e.g., heating rate, reaction time, flow rate) through improved heat and mass transfer in small tubular reactors, as well as faster and automated reactions[1].

The aim of this practical work is to synthesize $AgInS_2$ nanocrystals in aqueous medium using a continuous flow system (Fig. 1), including reagent and setup preparation (½ day) and to measure their optical properties and hydrodynamic size (½ day). It will take place at the Grenoble Interdisciplinary Research Institute (IRIG) at CEA Grenoble.

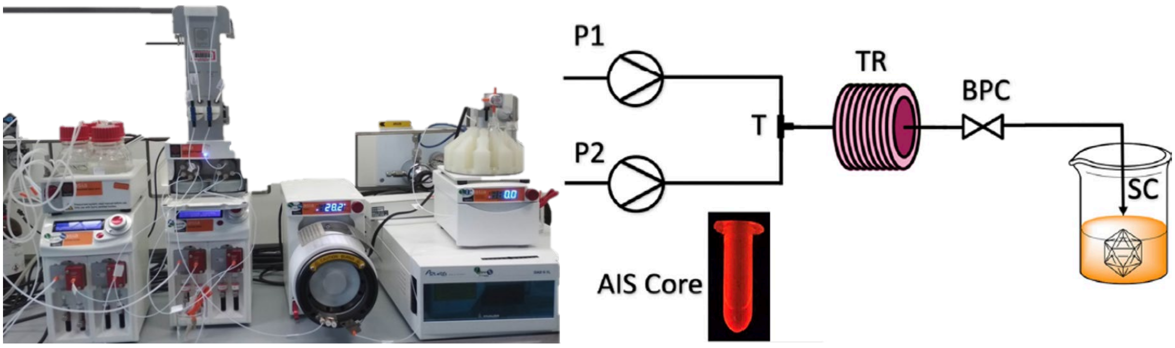

Figure 1: a) Photograph (left) and scheme (right) of the continuous flow system used for the synthesis of AIS core nanocrystals.

(1) Rivaux, C.; Akdas, T.; Yadav, R.; El-Dahshan, O.; Moodelly, D.; Ling, W. L.; Aldakov, D.; Reiss, P. Continuous Flow Aqueous Synthesis of Highly Luminescent AgInS2 and AgInS2/ZnS Quantum Dots. *J. Phys. Chem. C* **2022**, *126* (48), 20524–20534. https://doi.org/10.1021/acs.jpcc.2c06849.