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# Highly emitting perovskite quantum dots are finally available in water

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## Abstract

The interest on strongly emitting colloidal perovskite nanoparticles has been arisen explosively since several years. The versatility of the synthesis and the resulting scale-up, as well as high performance in terms of photoluminescence quantum yields and narrow spectra make these nanocrystals extremely attractive in optoelectronics. However, commonly known instability of these nanoparticles in aqueous environment is an important issue limiting their applications. This letter highlights a recent report by Geng et al. presenting direct aqueous synthesis of strongly emitting perovskite nanocrystals. One can foresee extrapolation of these results toward other perovskites including those based on Pb-free materials.

Since the seminal publications of Zhang et al.[1] and Protesescu et al.,[2,3] the interest on strongly emitting colloidal perovskite nanoparticles has explosively increased. Indeed, the versatility of the synthesis and the resulting potential scale-up, as well as high performance in terms of photoluminescence quantum yields and narrow spectral widths make these nanocrystals extremely attractive in optoelectronics, e.g. in light-emitting diodes (LEDs), display technologies, and lasing. Apart from those potential applications, strongly emitting materials with narrow emission and broad absorption bands are always demanded for bio-labelling and bio-imaging provided they possess reasonable stability in aqueous environment and in common biological buffers. Taking into account reported inherent instability of the lead–halide perovskites toward water, the research on making these nanocrystals water compatible was mainly focused on better ways of encapsulation. The shells based on polymers and oxides were suggested to increase the nanocrystal stability toward ambient conditions considering as a rule the exposure of the optoelectronic devices to humidity and atmospheric oxygen.[4,5] The resulting materials were typically reported as suspensions or dispersions of partly aggregated powders. If one, however, considers the applications in bio-environment, the size of an individual nanoparticles does matter a lot, and should be maintained as small as possible.[6] The about 30 years' experience of scientists dealing with colloidal quantum dots shows that the proper phase transfer to aqueous environment is a very challenging task demanding material-depending multistep procedures of designing and constructing a series of inorganic and organic stabilizing shells.[7] The alternative solution can be a direct synthesis in water environment. Although, the possible choice of nanoparticles, which can be synthesized in water delivering stable strongly emitting colloids is typically limited to the families of II–VI, I–III–VI and IV–VI semiconductors, optically active in the visible and near-infra-red part of the spectrum, there is no inherent limitations to the extending of this family toward other prominent members.[8,9] And this is exactly what happened recently with the report of Geng et al. presenting direct aqueous synthesis of $CH_3NH_3PbBr_3$ or $CH_3NH_3Pb(Br_xCl_{1-x})_3$ perovskite colloidal nanocrystals.[10] They were synthesized through the reaction between the lead–halide complex and methylamine, and the peculiarity of the synthesis is in keeping all the process under acidic pH in the range of 0–5, which was uncommon for most of the previously reported aqueous syntheses of metal halide quantum dots. At these synthetic conditions, a positive charged surface of perovskite nanocrystals, and a proper ionic balance are claimed by the authors to be responsible for preventing their decomposition in water. Additional surface capping with short-chain organic amine ligands further improves the PL quantum yield of the resulting perovskite quantum dots in water, reaching high values of 40%. The reasonably high, months long, colloidal stability in ambient conditions as well as photostability necessary to perform bio-imaging experiments are evidenced from the preliminary tests reported by the authors.

Taking into account the common belief on the inherent instability of lead halide perovskites in aqueous environment, the reported results may be considered as surprise. However, as the authors show, there is apparently no limitation from the chemical point of view allowing the scientists to solve this very important issue. Highlighting this pioneering work, we can soon foresee its extension toward strongly emitting multiply colored colloids of other perovskite nanocrystals stable in water, ideally including those based on Pb-free material combinations.

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