Perovskite Quantum Dots Luminescent Nanofluids as Biological Thermometer by Ratiometric Method

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Outline…

1. Introduction
2. Experimental
3. Results
4. Conclusions

Introduction…

- The measure of temperature is an important parameter in our environment, specially in biological media.

- For measuring *in vivo*, the development of methodologies that can permit the determination of changes in temperature, at cell scale, with good sensibility is a need.

- One strategy is the use of *nanothermometry*, where the luminescent emission of nanoparticles depends with temperature, and can be used as thermometer at the nanoscale.

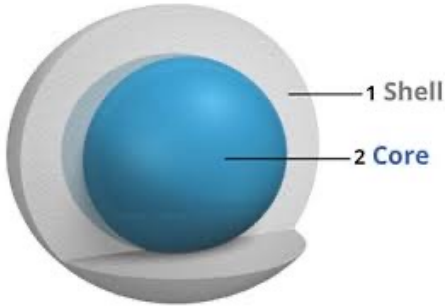
- The ideal nanothermometer must meet a series of premises such as excitation and emission within the biological windows (NIR), emission shift with temperature within the range 10-50 ºC, good photo and chemical stability and biocompatibility.

Introduction…

- For the determination of temperature, a ***ratiometric method*** can be applied.
- This method uses the linear relation between the intensity ratio of two emission bands of the nanoparticles at the excitation wavelength, and the inverse of temperature. So a good nanoparticle candidate should have two emission bands at the excitation wavelength.

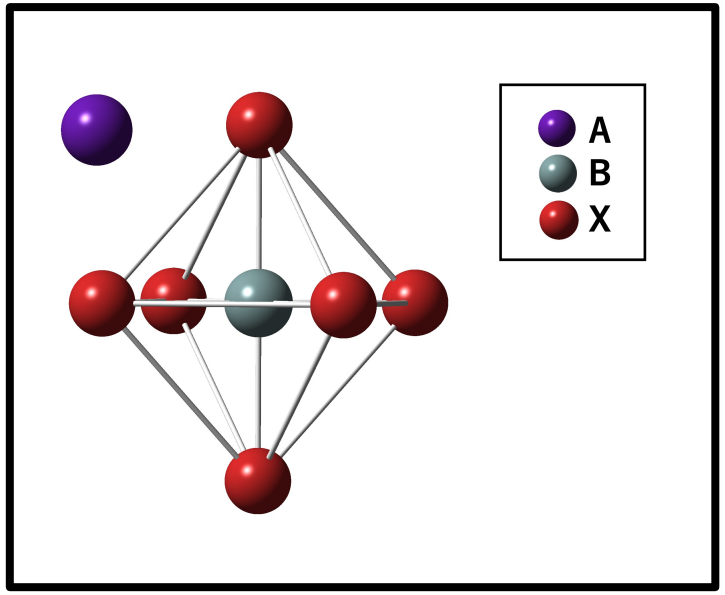
$$\log \frac{I_{\lambda_1}}{I_{\lambda_2}} = a + b\left(\frac{1}{T}\right)$$

- Good candidates could be nanoparticles of quantum dots and nanomaterials doped with rare earths in a core-shell structure, where the core are the quantum dots, and the shell is formed by the second material.



Introduction…

- This work is a starting point, representing first steps to the development of nanothermometer.
- Synthesis of ‘core’ nanoparticles with luminescent properties and preparation of nanofluid in non polar media



Perovskite structure

Luminescent nanofluid

Experimental…

- Synthesis of $CsPbBr_3$, $CsPbBr_{1.5}I_{1.5}$ and $CsPbI_3$ nanocrystals by <u>hot-injection method</u>

1. Preparation of cesium oleate solution (Cs_2CO_3 + oleic acid + octadecene)
2. Preparation of lead halide solution (PbX_2 + ODE + oleylamine + oleic acid)
3. Injection of cesium oleate over lead halide solution at 150 ºC
4. After 5 seconds, immersion of the flask in ice bath to stop the reaction
5. Centrifugation of the crude at 0 ºC. Nanocrystals are obtained as precipited

- Preparation of $CsPbBr_3$, $CsPbBr_{1.5}I_{1.5}$ and $CsPbI_3$ nanofluids

1. Dispersion of nanocrystals in anhydrous toluene.

Experimental…

- Characterization

1. Powder X-Ray Diffraction (XRD)
2. High Resolution Transmission Microscopy (HR-TEM)
3. Energy Dispersive X-ray Spectroscopy (EDS)
4. Photoluminescent Spectroscopy (PL)

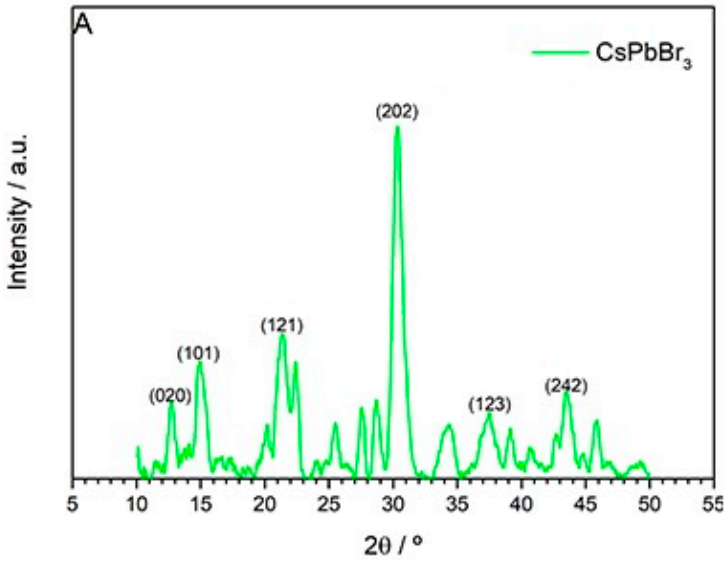
$CsPbBr_3$ $CsPbBr_{1.5}I_{1.5}$ $CsPbI_3$

Crude Nanofluid Crude Nanofluid Crude Nanofluid

Results…

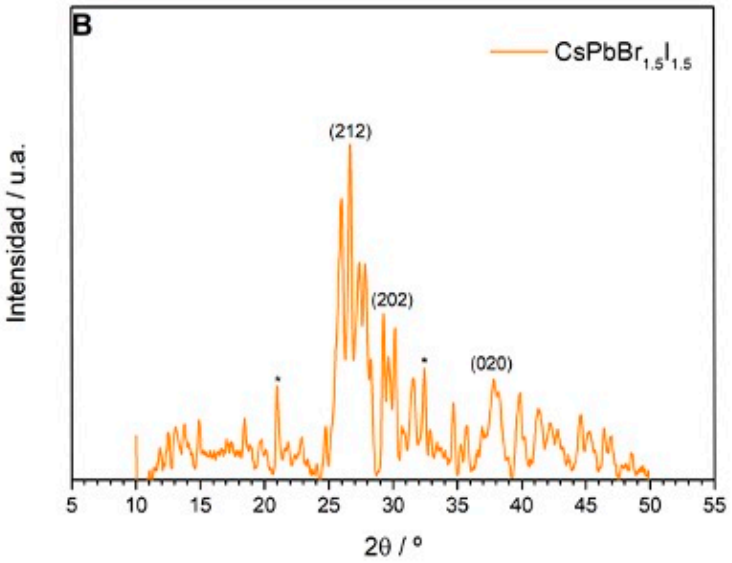
- Powder X-Ray Diffraction (XRD)

$CsPbBr_3$



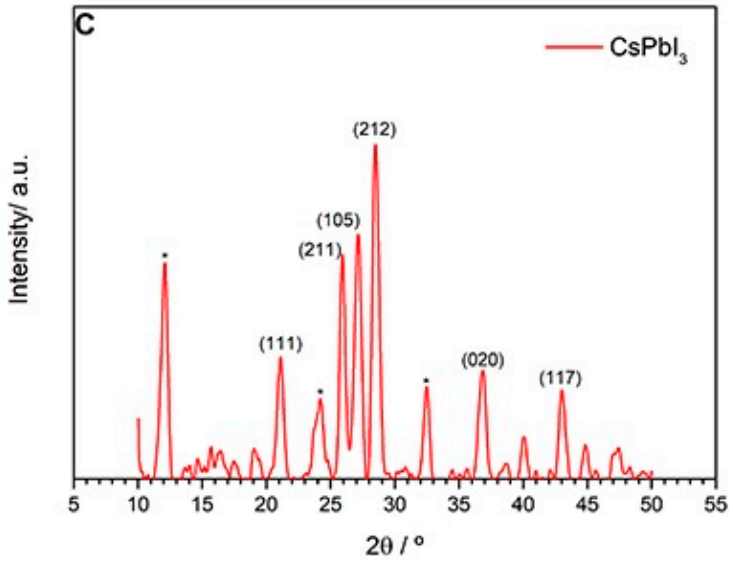
Orthorhombic

$CsPbBr_{1.5}I_{1.5}$



Orthorhombic

$CsPbI_3$

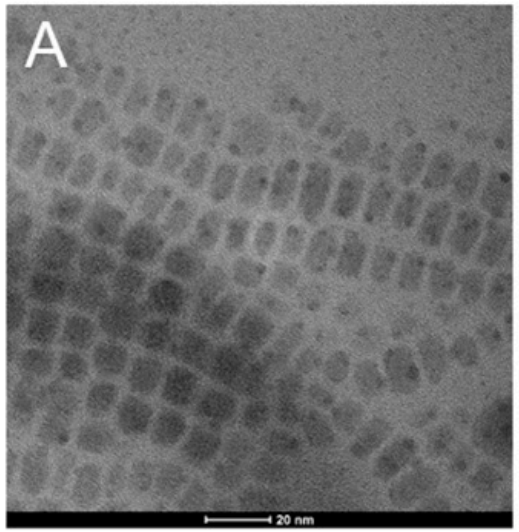


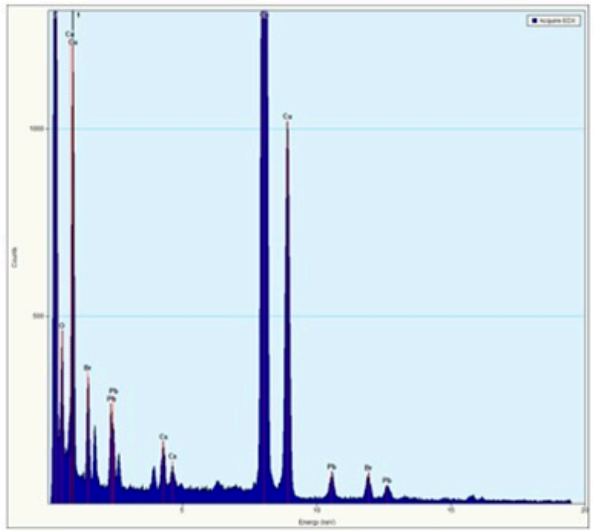
Cubic $\xrightarrow{< 24\ h}$ Orthorhombic

Results…

- High Resolution Transmission Microscopy (HR-TEM) / Energy Dispersive X-ray Spectroscopy (EDS)

$CsPbBr_3$

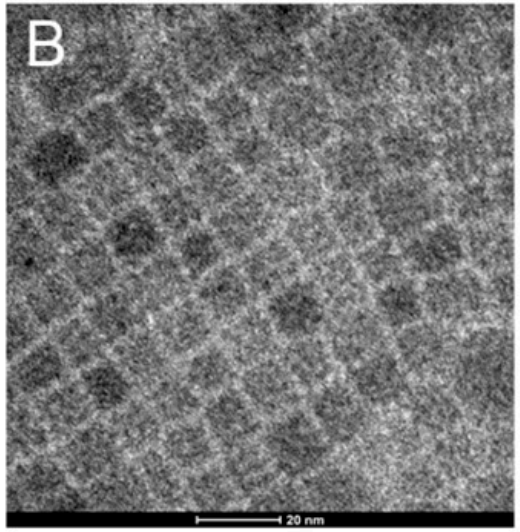


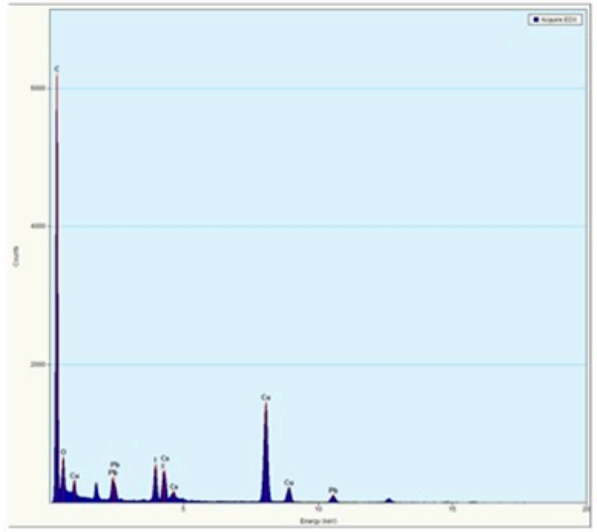


HR-TEM

EDS

$CsPbI_3$





HR-TEM

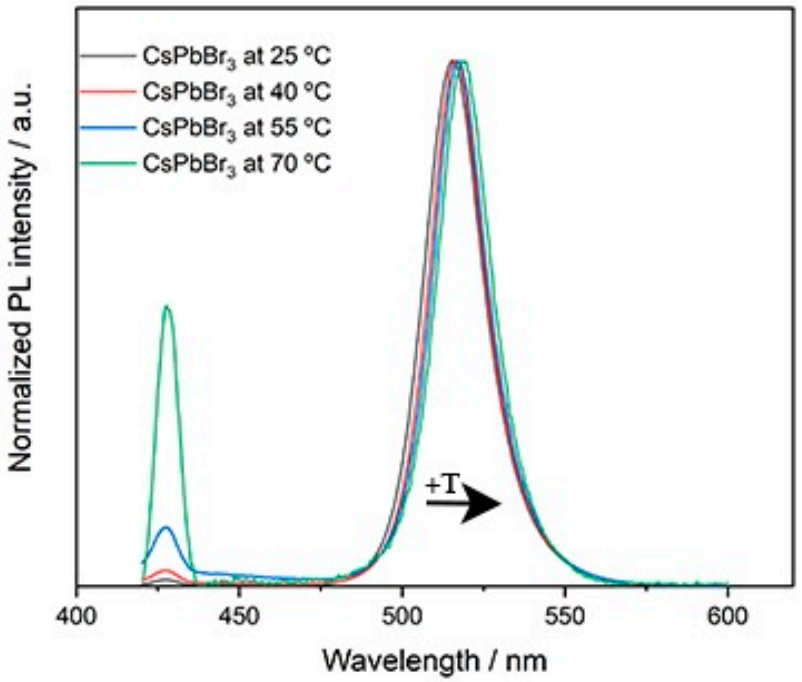
EDS

LESS THAN 20 nm

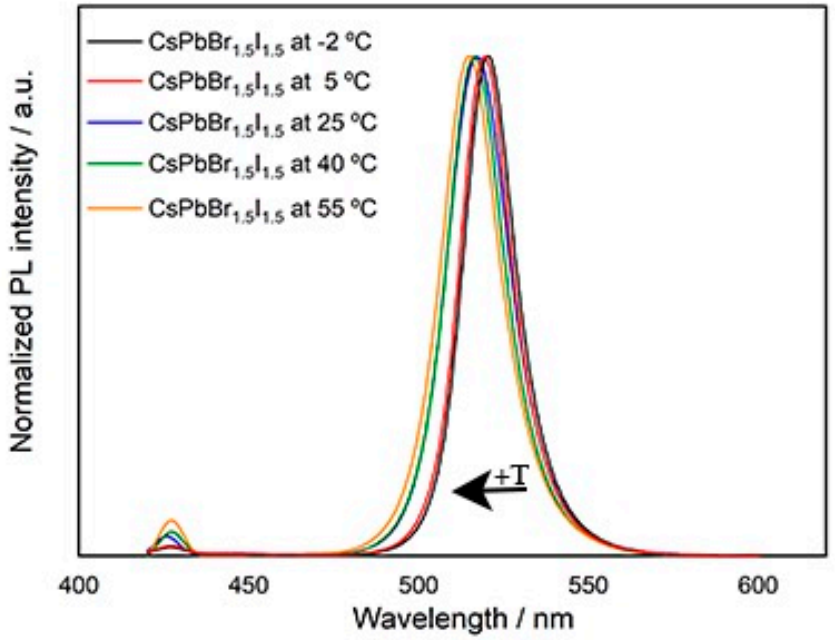
Results…

- Photoluminescent Spectroscopy (PL)

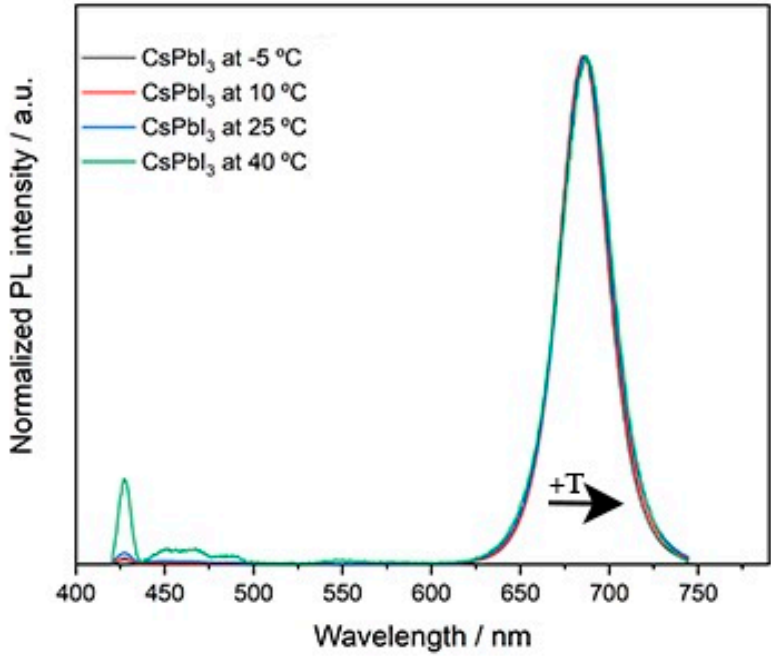
$CsPbBr_3$



$CsPbBr_{1.5}I_{1.5}$



$CsPbI_3$

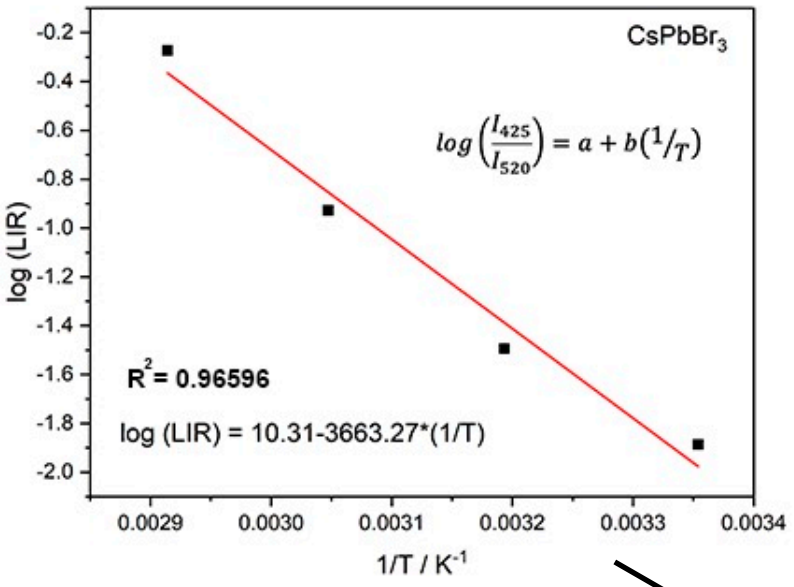


Results…

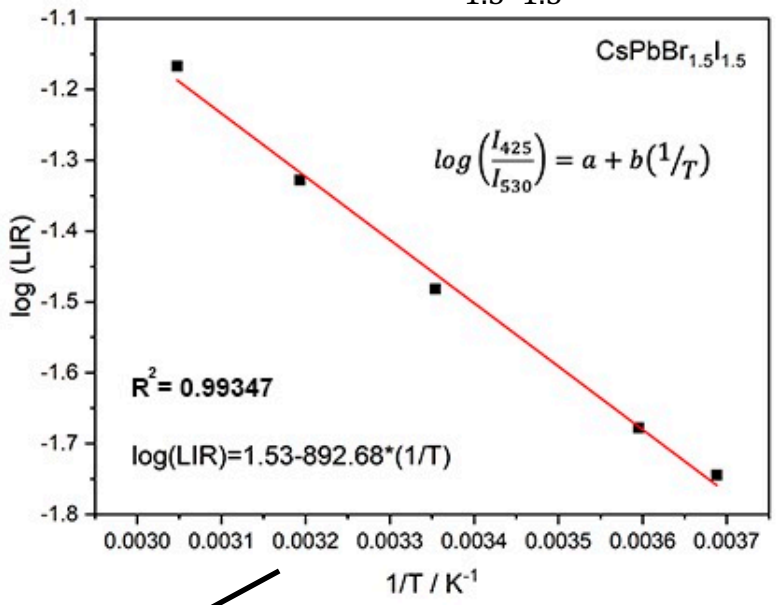
- Ratiometric method: Relation between emission and temperature

$$\log \frac{I_{\lambda_1}}{I_{\lambda_2}} = a + b\left(\frac{1}{T}\right)$$

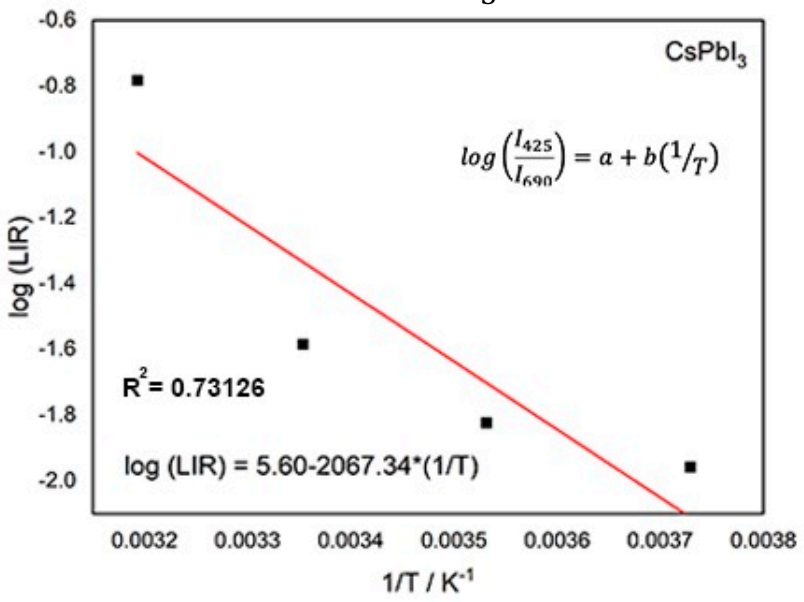
$CsPbBr_3$



$CsPbBr_{1.5}I_{1.5}$



$CsPbI_3$



BEST FIT

UNSTABLE

Conclusions…

- Three perovskites nanocrystals ($CsPbBr_{1-x}I_x$) have been synthesized by hot-injection method.
- Three nanofluids with the perovskites nanocrystals have been prepared.
- All nanofluid are luminescent with two emission band.
- A shift of emission to higher or lower wavelength with temperature in function of composition has been recorded.

Conclusions…

- A ratiometric method has been applied to establish a relation between band's emissions and temperature.
- $CsPbBr_{1.5}I_{1.5}$ based nanofluid shows the best results.
- Perovskite nanocrystals are good candidates as core particles in a core-shell structure.
- This work establishes a starting point to achieve a nanothermometer with application in biological media.

Thank you for your attention

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