Study of Perovskite Quantum Dots Synthesizing and Anion Exchanging

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Abstract

Quantum dots are semiconducting nano particles that show photoluminescent properties.
Among these particles, perovskite quantum dots show a significant importance because they show enhanced PL emissions with a high quality color, compared to conventional quantum dots. Therefore, they have promising applications in optoelectronic devices.
In this project we explored the properties of lead halide perovskite quantum dots(CsPbX3, X = Cl, Br, I), from their synthesis to their applications.
We synthesized each type of quantum dot using different kinds of halide sources and aimed making a total spectrum by synthesizing hybrid halide quantum dots.
Additionally, the PL of each synthesized material was evaluated.
We also used the anion exchange method, another concept of creating hybrid halide quantum dots instead of synthesizing them.
After that, we did quantum dot patterning on a glass substrate using anion exchange.

Introduction

Cesium Lead Halide Perovskite QD

▸ What is Perovskite Quantum Dots?
- Study of method for producing quantum dots with controlled size and high ensemble uniformity

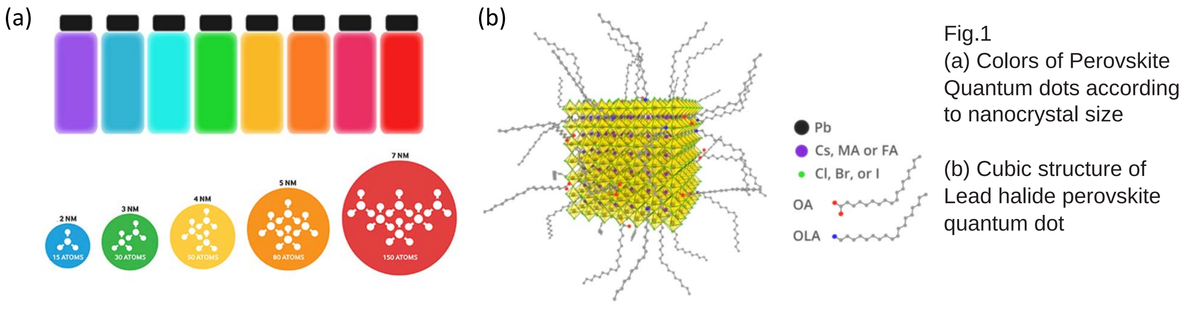
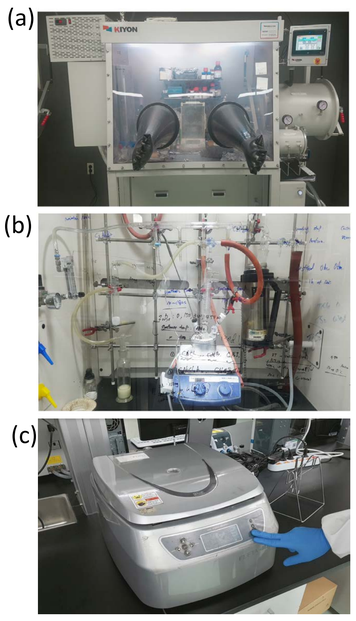


Fig.1
(a) Colors of Perovskite Quantum dots according to nanocrystal size

(b) Cubic structure of Lead halide perovskite quantum dot

Synthesis & Purification

Materials & Equipment



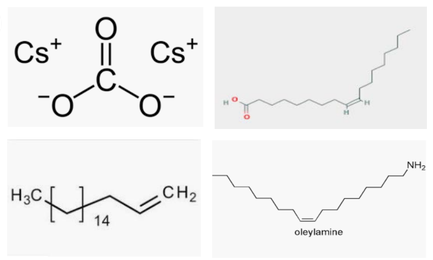


Fig.2 Images of laboratory apparatus (a) Glove box
(b) Schlenk Line
(c) Centrifuge

(d) Structure of Cs_2CO_3, Oleic acid(OA), 1-octadecene(ODE), Oleylamine(OAm) also PbX_2 and ZnX_2 are used.
Cs_2CO_3 0.25g + OA 0.8g + ODE 7g at 150℃ → Cs-oleate

Method & Result

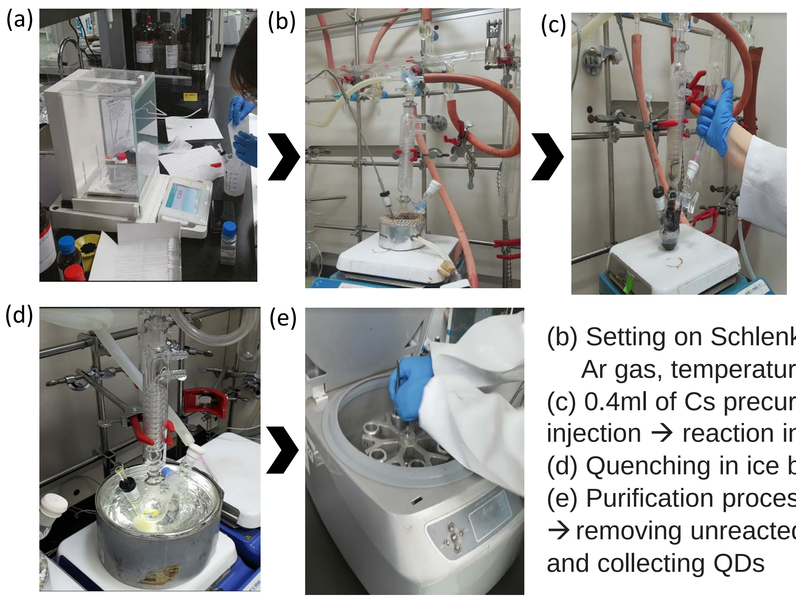


Fig.3 Experiment Procedure
(a) PbX_2 75mg + ZnX_2 0~600mg + ODE 5ml + OA 2ml + Oam 2ml in three-necked round-bottomed flask

(b) Setting on Schlenk line with Ar gas, temperature 120 ℃
(c) 0.4ml of Cs precursor solution injection → reaction initiation
(d) Quenching in ice bath
(e) Purification process
→removing unreacted salts and collecting QDs

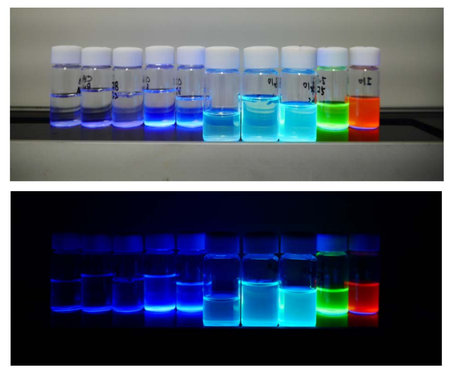


Fig.4 Images of synthesized perovskite Quantum dots.
Ultra Violet lamp off / on condition
$CsPbCl_3$ → $CsPbBr_3$ → $CsPbI_3$

Experiments

Method

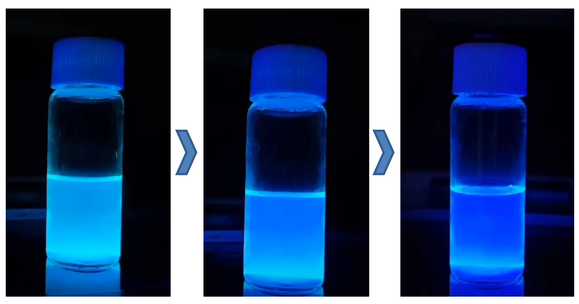


Fig5 Images of color of $CsPbBr_3$ quantum dots + chloroform changing according to UV lamp exposure time

Dispersion of QDs on Substrate is possible by spin-coater

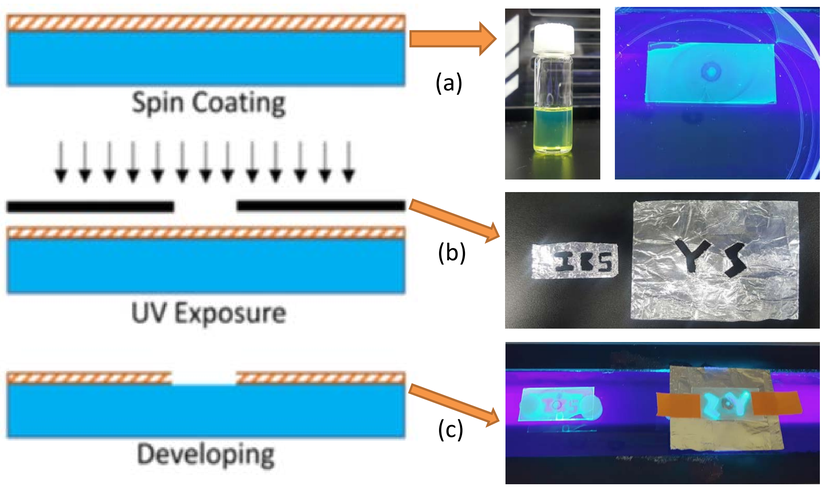


Fig.6 Procedure of Anion Exchanging
(a) Preparation
- PMMA
- Glass substrate
- Synthesized Quantum dots

Disperse Quantum dots in PMMA and spin-coat on glass substrate.

(b) Photomask (opaque to UV, Aluminum foil)

(c) Expose to UV light

Application & Technology

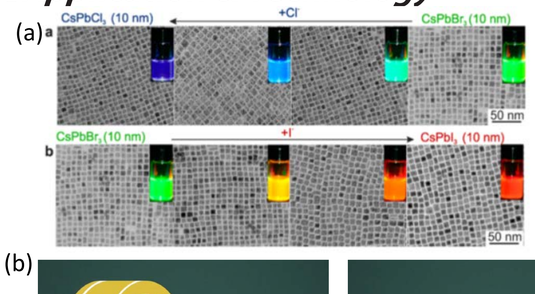


Fig.7 (a) Transmission electron microscopy (TEM) images of ~10 nm CsPbX3 NCs after treatment with various quantities of chloride and iodide anions.

(b) Application and potential of PQDs

Measurement

TEM(Transmission Electron Microscope)

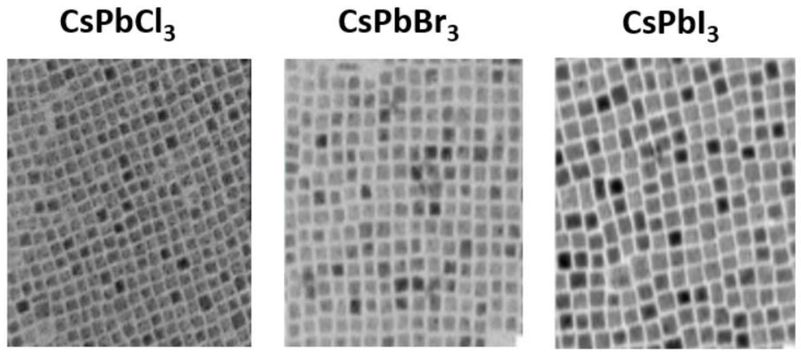


Fig.8 Transmission electron microscopy (TEM) images of Perovskite quantum dots.
The QD size is a function of the both Br-to-Pb ratio and the reaction temperature.

* Fixed temperature : the QD size decreased with increasing Br-to-Pb ratio.
the QD size decreased with decreasing temperature.

PL(Photoluminescence) Spectra Measuring

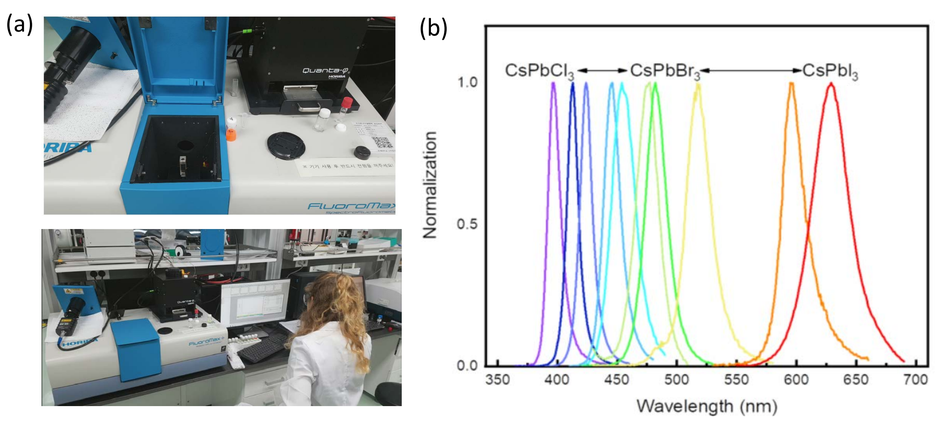


Fig.9 PL spectra Measurement
(a) PL measuring of Synthesized QDs By Fluoromax

(b) Measured PL Spectrum of QDs according to emitting light wavelengths

Anion Exchange Result

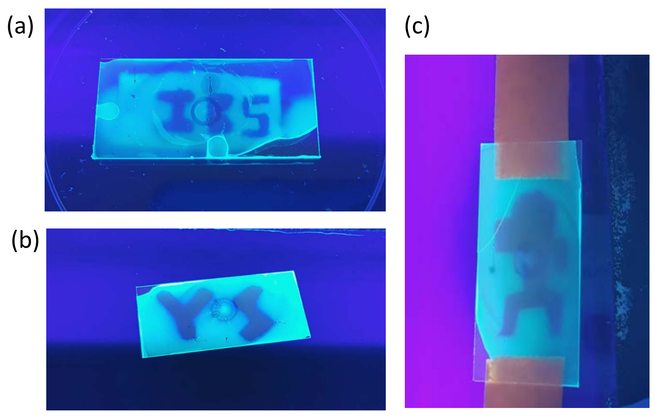


Fig.10 Images of anion exchange patterning
(a) Word 'IBS' patterning
- Exposure time 10 min

(b) Word 'YS'(yonsei) patterning
- Exposure time 15 min

(c) Human character shape patterning
- Exposure time 10 min

Conclusion

1. Study of using apparatus such as Schlenk line, Glove box, centrifuge was performed
2. Understand of whole procedure including preparation–synthesis–purification–storing
3. Learning of measurement method including TEM, PL spectra
4. Fine adjustments of time can make the detailed color difference in anion exchange
5. Patterning experiment has many error factors such as perfection of spin coating and ultra violet lamp blocking mask
6. Further study of application and technology of QDs in various fields.

References

References

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