

Supporting Information

Synthesis and luminescence of Al based double perovskite quantum dots

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Supporting information

1 Reagents and instruments

1.1 Reagents

Cesium Acetate, 98%, Shanghai BiDe PharmaTech; Silver Acetate, >98%, Shanghai BiDe PharmaTech; Sodium Acetate, >98%, Shanghai BiDe PharmaTech; Aluminum Acetate, Analytically Pure, Bismuth Acetate, 98%, Shanghai BiDe PharmaTech Shandong West Asia Chemical Co. Ltd; ammonium oleate, analytical pure, Shanghai Aladdin Biochemical Technology Co., Ltd; octadecene, analytical pure, Beijing Anegi Energy Engineering Technology Co. n-trioctylphosphine, 98%, Shanghai Aladdin Biochemical Technology Co., Ltd; The above drugs are used directly without special treatment.

1.2 Instrumentation

Lambda 1050+ UV-Vis NIR spectrophotometer, PerkinElmer, USA; FLS1000 Steady transient fluorescence spectrometer, Edinburgh, UK; F200 projection electron

microscope, Nippon Electron Corporation; ES CALAB 250Xi X-ray photoelectron spectrometer, Thermo Fisher Scientific, USA.

2 Experimental section

2.1 Synthesis of Cs₂AgAlCl₆ QDs.

CsOAc, In(OAc)₃, Al(OAc)₃ and AgOAc were loaded into a two-necked round-bottomed flask, and three pumping and three releasing (pumping three times of vacuum and filling three times of nitrogen, alternately) were carried out in an oxygen-free and water-free operating system, and a nitrogen balloon was inserted into one end of the two-necked round-bottomed flask as a protective gas. Then ODE, oleic acid OA, oleylamine OAm were injected, and the temperature was heated to 110 °C until all the raw materials were dissolved. The temperature was continued to 155 °C, and TMS-Cl was injected immediately when the temperature rose to 155 °C, and the reaction was carried out for 30 s. The reaction was then subjected to an ice bath and cooled to room temperature. The product was transferred to a 10 ml centrifuge tube and centrifuged at 8000 rpm for 10 min, the supernatant was discarded, and then the precipitate was dissolved in n-hexane and centrifuged at 8000 rpm for 10 min, the supernatant was taken and the precipitate was discarded. The supernatant was removed and the precipitate was discarded. The hexane was evaporated at 69 °C and concentrated. Subsequently, an equal amount of ethyl acetate was added for purification. The final precipitate was collected by centrifugation at 8000 rpm for 10 min.

2.2 Synthesis of Cs₂NaAlCl₆ QDs.

CsOAc, In(OAc)₃, Al(OAc)₃ and NaOAc were loaded into a two-necked round-bottomed flask, and three pumping and three releasing (pumping three times of vacuum and filling three times of nitrogen, alternately) were carried out in an oxygen-free and water-free operating system, and a nitrogen balloon was inserted into one end of the two-necked round-bottomed flask as a protective gas. Then ODE, oleic acid OA, oleylamine OAm were injected, and the temperature was heated to 110 °C until all the raw materials were dissolved. The temperature was continued to 155 °C, and TMS-Cl was injected immediately when the temperature rose to 155 °C, and the reaction was carried out for 30 s. The reaction was then subjected to an ice bath and cooled to room temperature. The product was transferred to a 10 ml centrifuge tube and centrifuged at 8000 rpm for 10 min, the supernatant was discarded, and then the precipitate was dissolved in n-hexane and centrifuged at 8000 rpm for 10 min, the supernatant was

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2.3 Synthesis of Bi-Cs₂AgAlCl₆ QDs (20%,40%,60%,80%,100%).

CsOAc, Al(OAc)₃, AgOAc and Bi(OAc)₃ (20%,40%,60%,80%,100%) were loaded into a two-necked round-bottomed flask, and three pumping and three releasing (pumping three times of vacuum and filling three times of nitrogen, alternately) were carried out in an oxygen-free and water-free operating system, and a nitrogen balloon was inserted into one end of the two-necked round-bottomed flask as a protective gas. Then ODE, oleic acid (OA), oleylamine (OAm) were injected, and the temperature was heated to 110 °C until all the raw materials were dissolved. The temperature was continued to 155 °C, and TMS-Cl was injected immediately when the temperature rose to 155 °C, and the reaction was carried out for 30 s. The reaction was then subjected to an ice bath and cooled to room temperature. The product was transferred to a 10 ml centrifuge tube and centrifuged at 8000 rpm for 10 min, the supernatant was discarded, and then the precipitate was dissolved in n-hexane and centrifuged at 8000 rpm for 10 min, the supernatant was taken and the precipitate was discarded. The supernatant was removed and the precipitate was discarded. The hexane was evaporated at 69 °C and concentrated. Subsequently, an equal amount of ethyl acetate was added for purification. The final precipitate was collected by centrifugation at 8000 rpm for 10 min.

2.4 Synthesis of Bi-Cs₂NaAlCl₆ QDs (20%,40%,60%,80%,100%).

CsOAc, Al(OAc)₃, NaOAc and Bi(OAc)₃ (20%,40%,60%,80%,100%) were loaded into a two-necked round-bottomed flask, and three pumping and three releasing (pumping three times of vacuum and filling three times of nitrogen, alternately) were carried out in an oxygen-free and water-free operating system, and a nitrogen balloon was inserted into one end of the two-necked round-bottomed flask as a protective gas. Then ODE, OA, OAm were injected, and the temperature was heated to 110 °C until all the raw materials were dissolved. The temperature was continued to 155 °C, and TMS-Cl was injected immediately when the temperature rose to 155 °C, and the reaction was carried out for 30 s. The reaction was then subjected to an ice bath and cooled to room temperature. The product was transferred to a 10 ml centrifuge tube and centrifuged at 8000 rpm for 10 min, the supernatant was discarded, and then the

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2.5 Synthesis of TOP-Cs₂AgAlCl₆ QDs (20%,40%,60%,80%).

CsOAc, Al(OAc)₃, AgOAc were loaded into a two-necked round-bottomed flask, and three pumping and three releasing (pumping three times of vacuum and filling three times of nitrogen, alternately) were carried out in an oxygen-free and water-free operating system, and a nitrogen balloon was inserted into one end of the two-necked round-bottomed flask as a protective gas. Then ODE, OA and n-triethylphosphine TOP (20%, 40%, 60%, 80%), OAm (80%, 60%, 40%, 20%) were injected, and the temperature was heated to 110 °C until all the raw materials were dissolved. The temperature was continued to 155 °C, and TMS-Cl was injected immediately when the temperature rose to 155 °C, and the reaction was carried out for 30 s. The reaction was then subjected to an ice bath and cooled to room temperature. The product was transferred to a 10 ml centrifuge tube and centrifuged at 8000 rpm for 10 min, the supernatant was discarded, and then the precipitate was dissolved in n-hexane and centrifuged at 8000 rpm for 10 min, the supernatant was taken and the precipitate was discarded. The supernatant was removed and the precipitate was discarded. The hexane was evaporated at 69 °C and concentrated. Subsequently, an equal amount of ethyl acetate was added for purification. The final precipitate was collected by centrifugation at 8000 rpm for 10 min.

3. Supporting figures

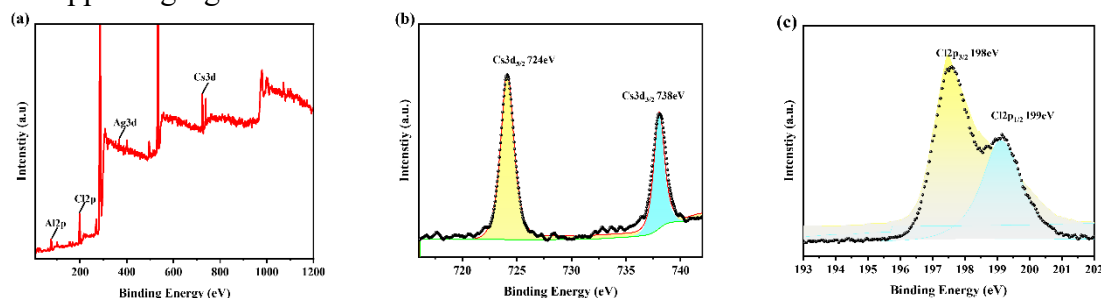


Figure S1 Cs₂AgAlCl₆ QDs: (a) XPS full spectrum, (b c) XPS fine spectra corresponding to Cs 3d, and C 1s, respectively

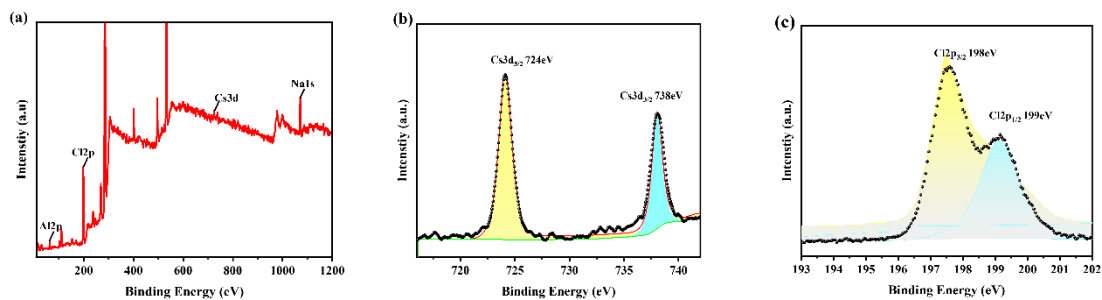


Figure S2 Cs₂NaAlCl₆ QDs: (a) XPS full spectrum, (b c) XPS fine spectra corresponding to Cs 3d, and Cl 2p, respectively

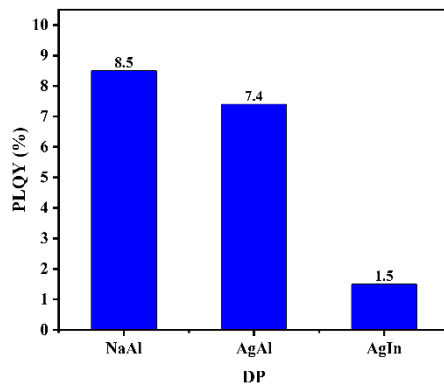


Figure S3 PLQYs of Cs₂AgAlCl₆, Cs₂NaAlCl₆ and Cs₂AgInCl₆ QDs, respectively.