

Tetrapod-shaped quantum dots with secondary excitonic luminescence

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TEM images were recorded on LEO912AB OMEGA microscope (100 kV). XRD data were measured on a DRON-3M diffractometer with Cu-K α anode. Composition was measured by Mistral M1 (Bruker) XRF spectrometer (for more details see Online Supplementary Materials). The optical measurements were performed on hexane sols of QDs in acrylic cuvettes. The fluorescence measurements were carried out with a 405 nm 40 mW laser excitation and detected by an Ocean Optics 4000 USB spectrometer calibrated by a 2600 K W-lamp (450–1100 nm). The UV-VIS absorption was studied with a Varian Cary 50 spectrophotometer from 300 to 1000 nm. Lifetime was measured using a 337,5 nm pulsed Kr⁺² laser (1 mJ, 13 ns and repetition rate 15 Hz). Signal was selected by MDR-23 monochromator with groove density 1200 mm⁻¹. Spectral width of slit was 5 nm. Signal was detected by photomultiplier PMT-62 and was transmitted to oscilloscope DSO1202B (Hantek, 200 MHz).

Table S1 Amount of dopants in reaction mixture and characteristics of quantum dots based on TEM images.

Sample ID	Amount of dopants, % mol relative to Cd	Mean diameter of branches, d , nm	Mean length of branches, l , nm
CdSe	-	$3,1 \pm 0,8$ (diameter)	
Er50	10% of erbium propionate with 7% weight Cl ⁻ ions	$3,4 \pm 0,7$ (diameter)	
Er100	20%	$2,8 \pm 0,5$	$8,3 \pm 1,3$
Er150	30%	$3,0 \pm 0,3$	$11,2 \pm 1,9$
Er200	40%	$3,2 \pm 0,5$	$12,3 \pm 1,8$
Er300	60%	$3,1 \pm 0,3$	$11,4 \pm 2,0$
Er500	100%	$3,5 \pm 0,4$	$19,0 \pm 2,0$
CdSe(Cd)	Exces of cadmium oleate	$2,9 \pm 0,6$ (diameter)	
Cd300	60% of CdCl ₂	$3,1 \pm 0,4$	$17,6 \pm 1,9$
Zn300	60% of ZnCl ₂	$3,3 \pm 0,4$	$21,8 \pm 1,8$
Yb300	60 % ytterbium propionate + 7% wt chloride ions	$3,1 \pm 0,4$	$25,2 \pm 2,0$

Determination of composition by XRF.

A series of standard samples was prepared and a calibration curve was obtained from measurements. The analytical signal was determined as relation of Er L line integral intensity to Cd K line integral intensity.

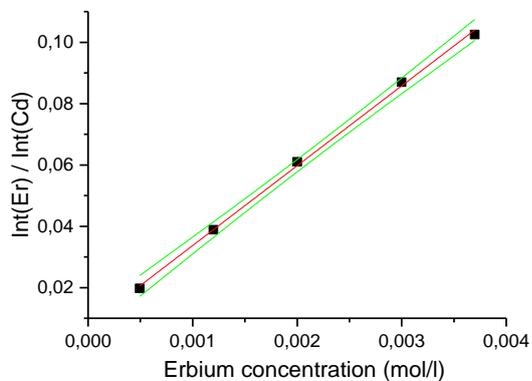


Figure S1 Calibration curve for determination of erbium concentration in samples of quantum dots.

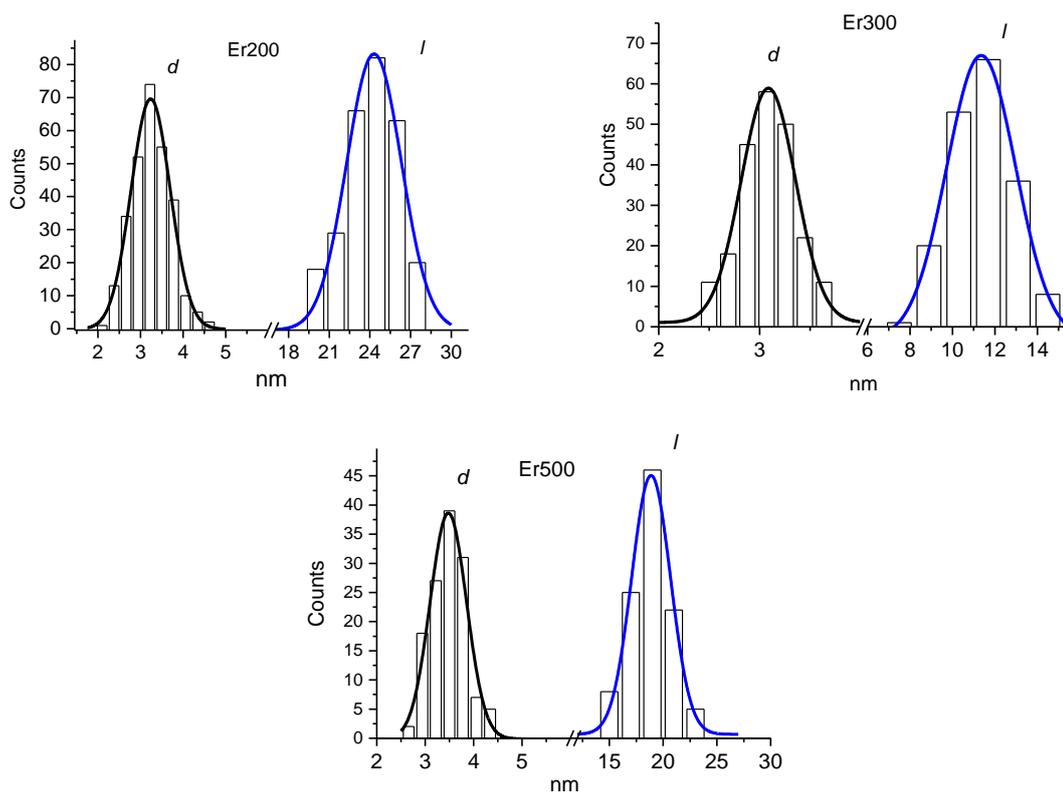


Figure S2 Size distributions of tetrapod-shaped quantum dots. Diameter (*d*) and length (*l*) of branches are shown.

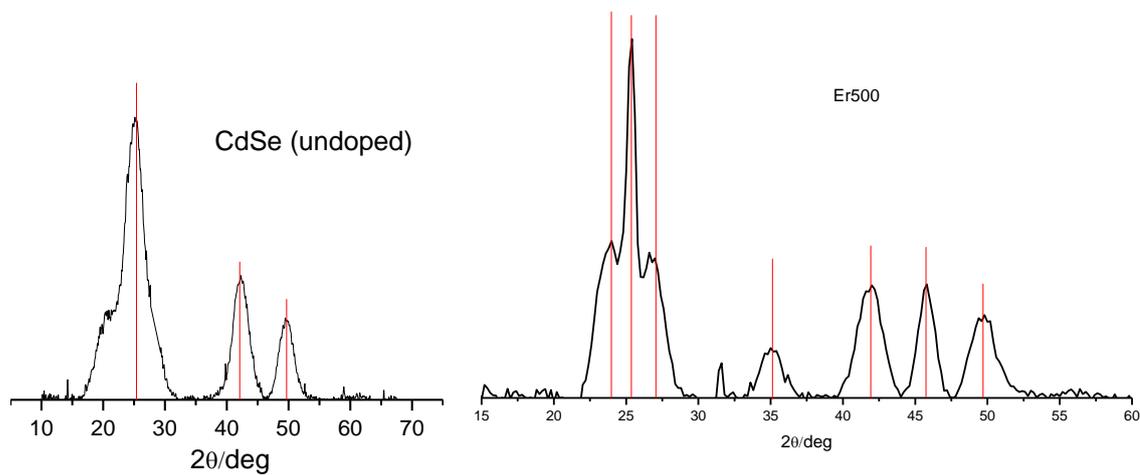


Figure S3 XRD spectra for undoped CdSe and Er500 sample.

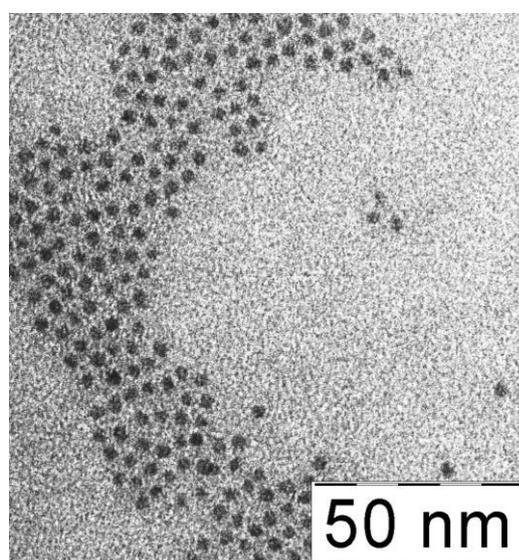


Figure S4 Transition electron microscopy of quantum dots sample obtained in the presence of Cd oleate excess.

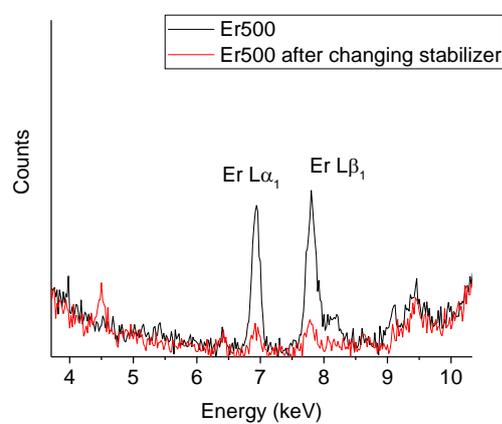


Figure S5 XRF of Er500 sample before and after changing of oleate stabilizer.

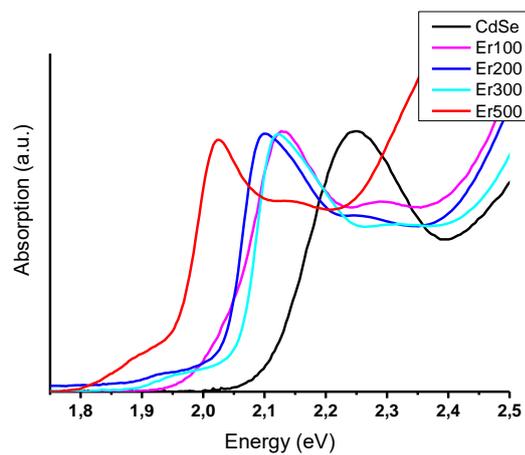


Figure S6 Absorption spectra of samples containing erbium.

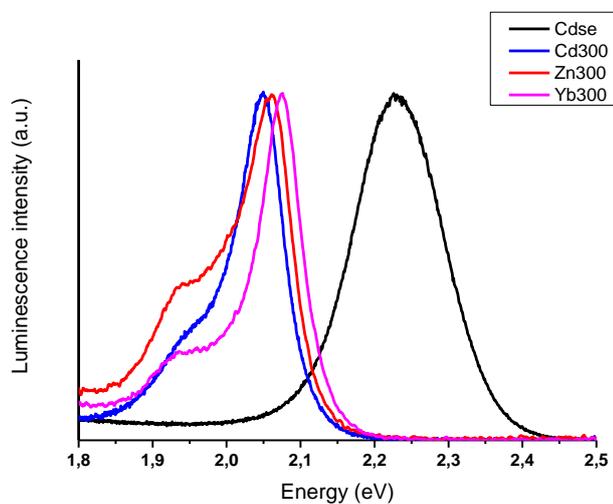


Figure S7 Normalized spectra of luminescence of quantum dots, obtained in the presence of CdCl_2 , ZnCl_2 , Yb^{3+} and Cl^- ions. Undoped CdSe, obtained in the same conditions is shown for reference.

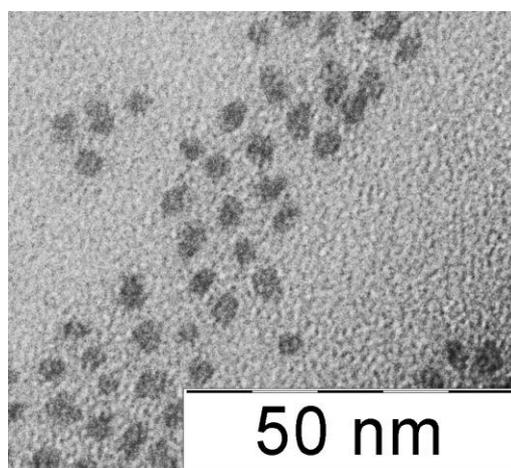


Figure S8 TEM of sample with Yb but without Cl^- ions.

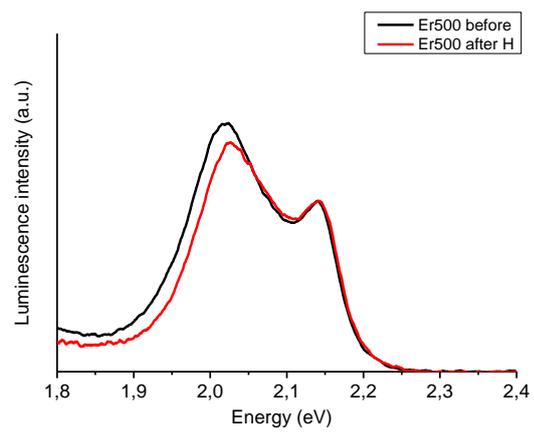


Figure S9 Reduction of Er500 sample by atomic H.