

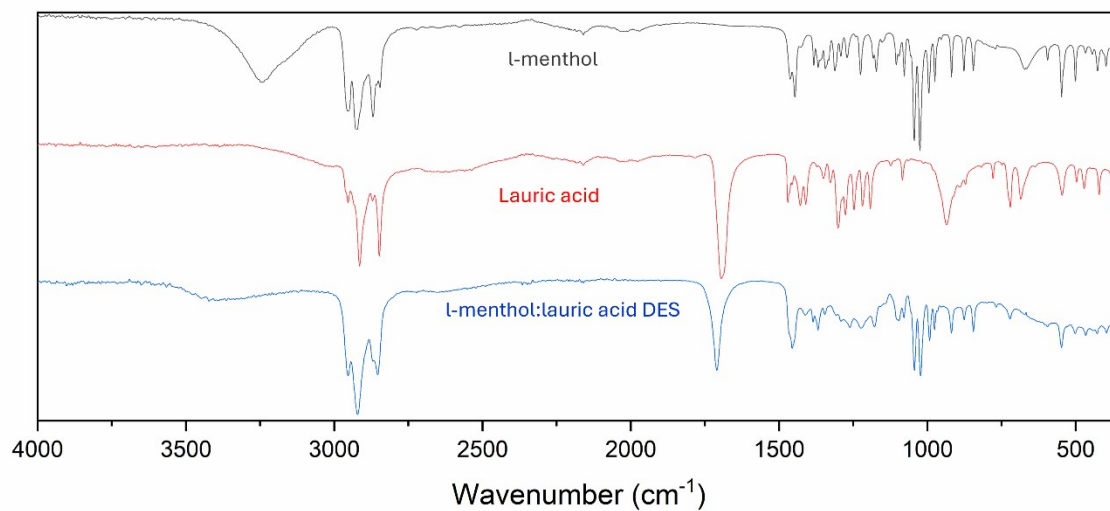
Electronic Supplementary Information for:

# Green Deep-Eutectic Synthesis of Multinary Quantum Dots for Luminescent Polymeric Composites and LED Applications

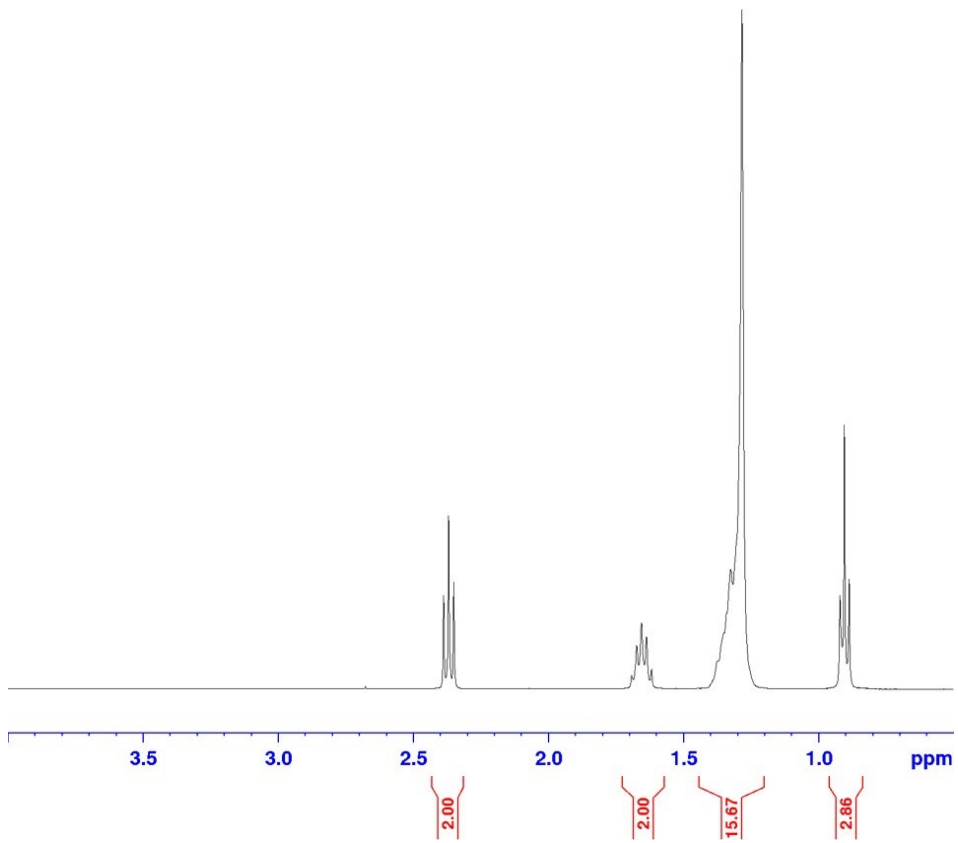
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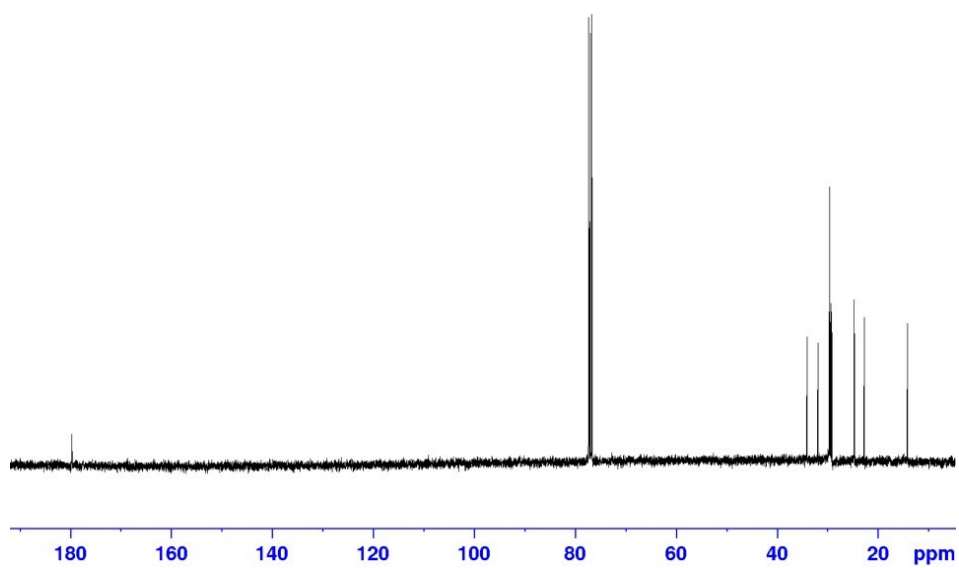
Emails: [branzil@tcd.ie](mailto:branzil@tcd.ie), [Igounko@tcd.ie](mailto:Igounko@tcd.ie)



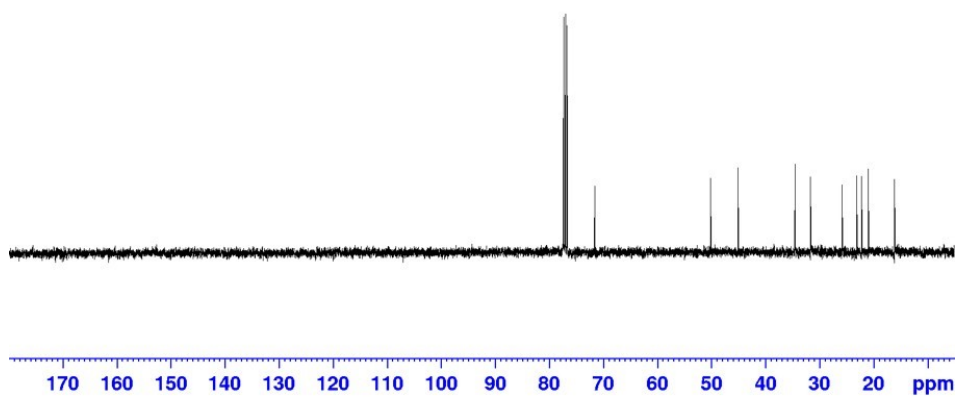
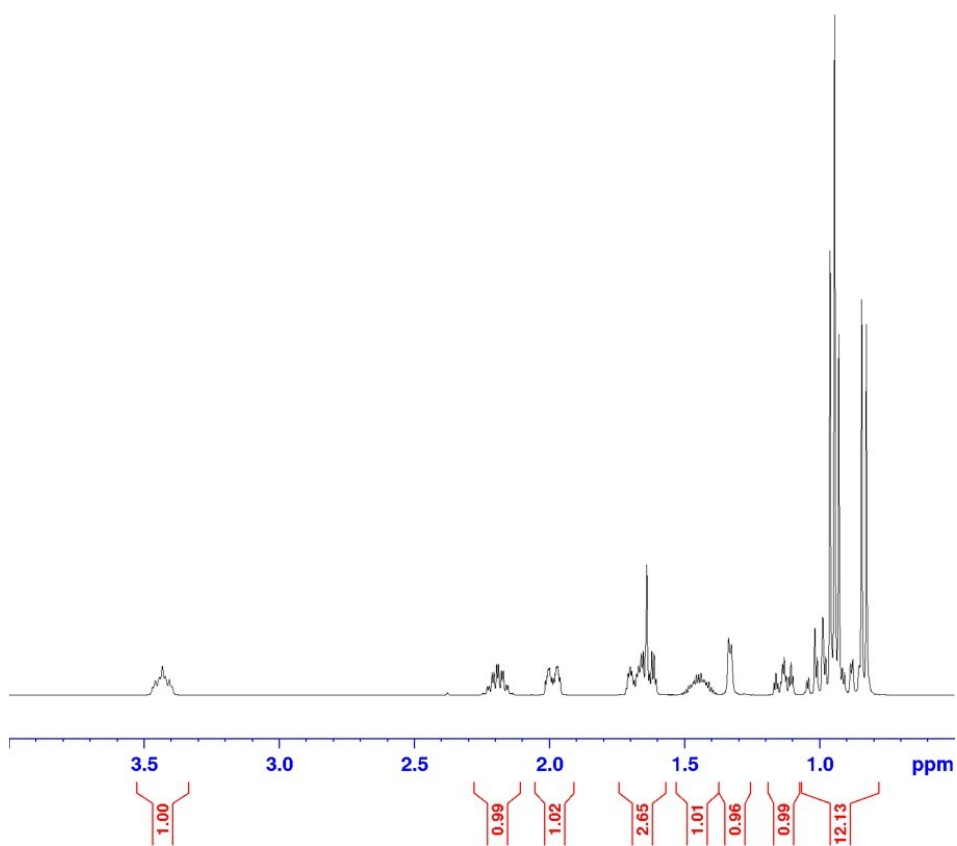
**Figure S1** FTIR analysis of l-menthol, lauric acid and the l-menthol lauric acid DES.



**Figure S2**  $^1\text{H-NMR}$  spectrum of lauric acid in  $\text{CDCl}_3$

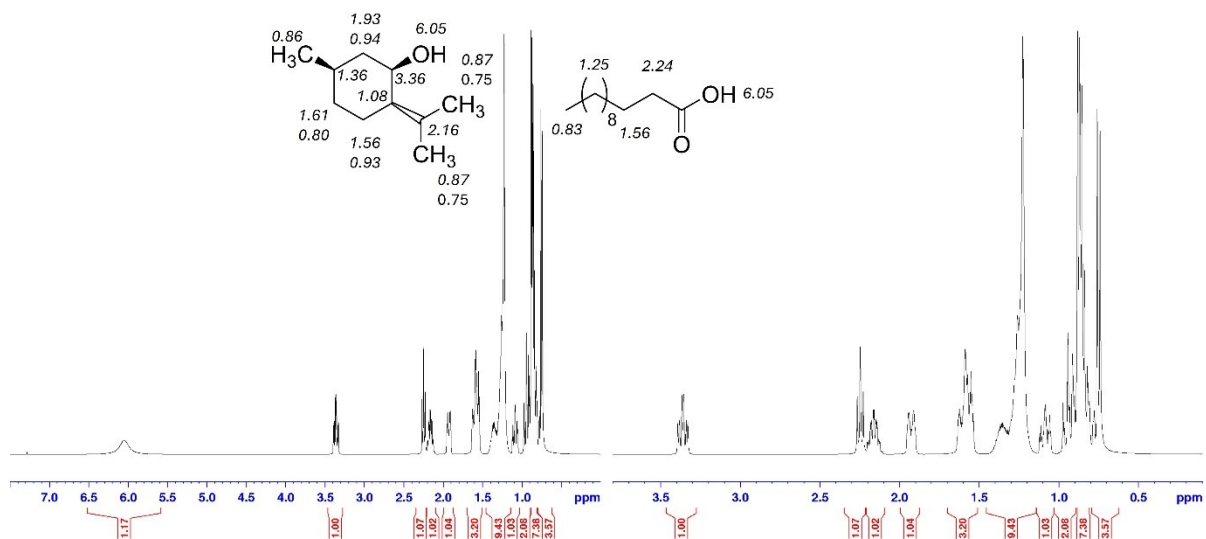


**Figure S3**  $^{13}\text{C-NMR}$  spectrum of lauric acid in  $\text{CDCl}_3$

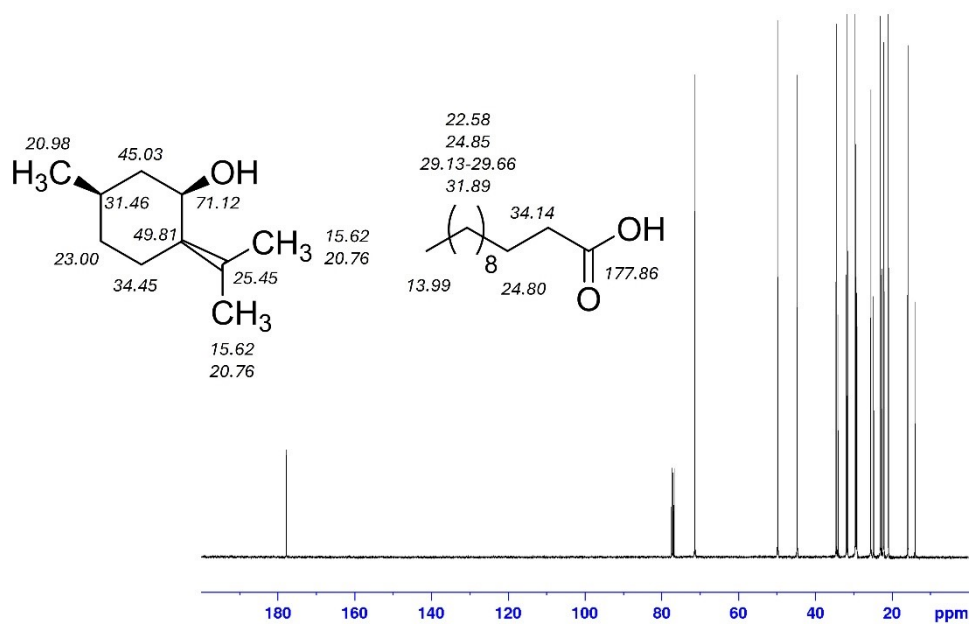


**Figure S4** <sup>1</sup>H-NMR spectrum of l-menthol in CDCl<sub>3</sub>

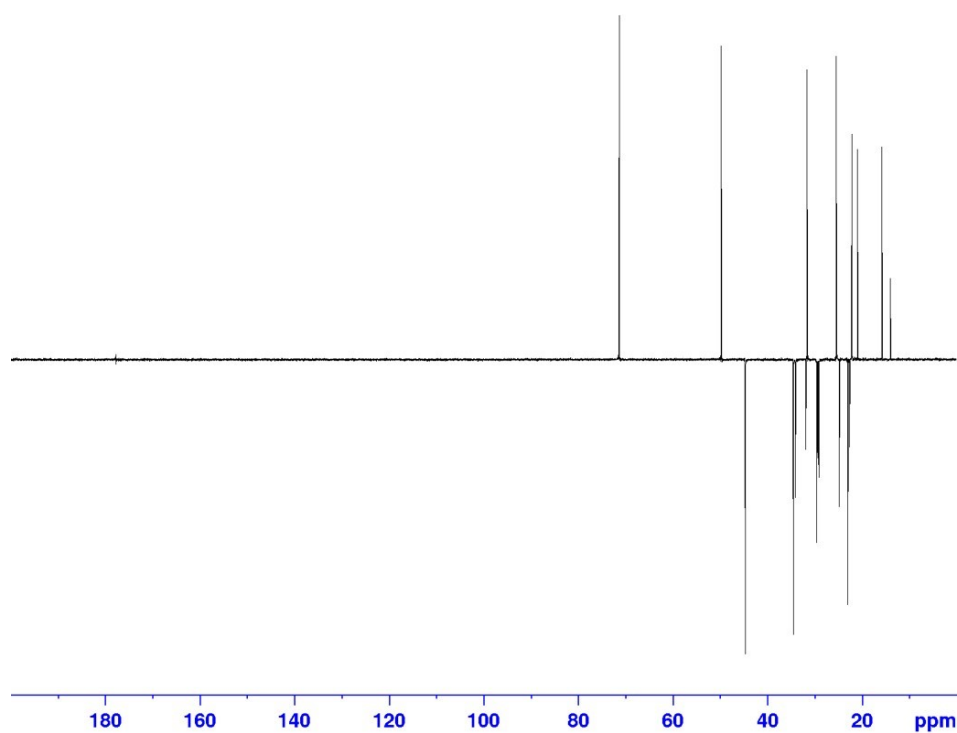
**Figure S5** <sup>13</sup>C-NMR spectrum of l-menthol in CDCl<sub>3</sub>



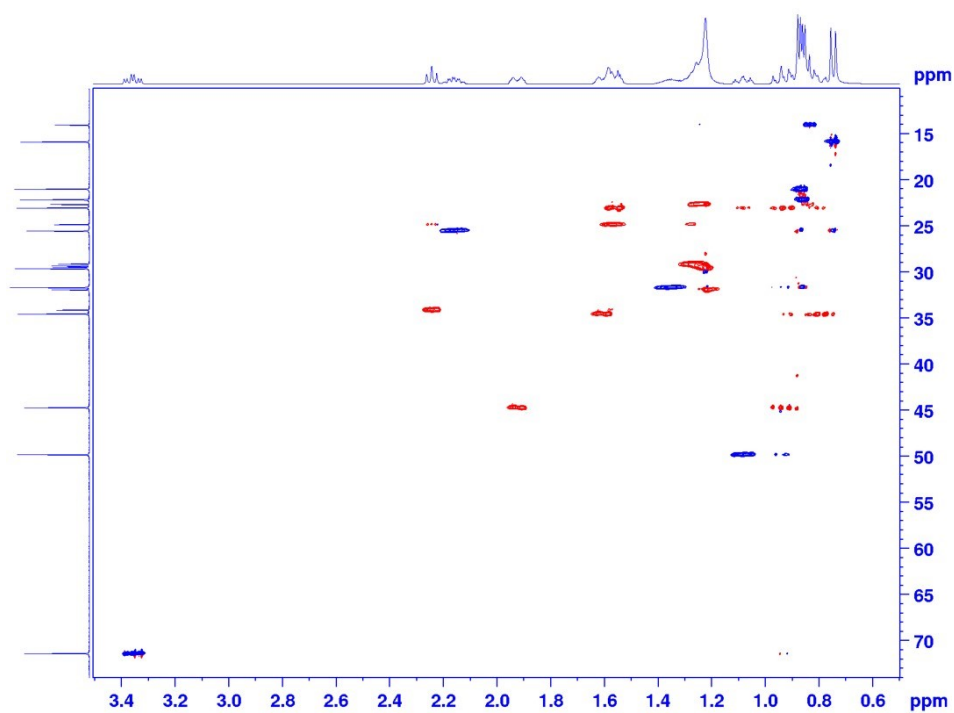
**Figure S6**  $^1\text{H-NMR}$  spectrum of l-menthol lauric acid DES in  $\text{CDCl}_3$ .



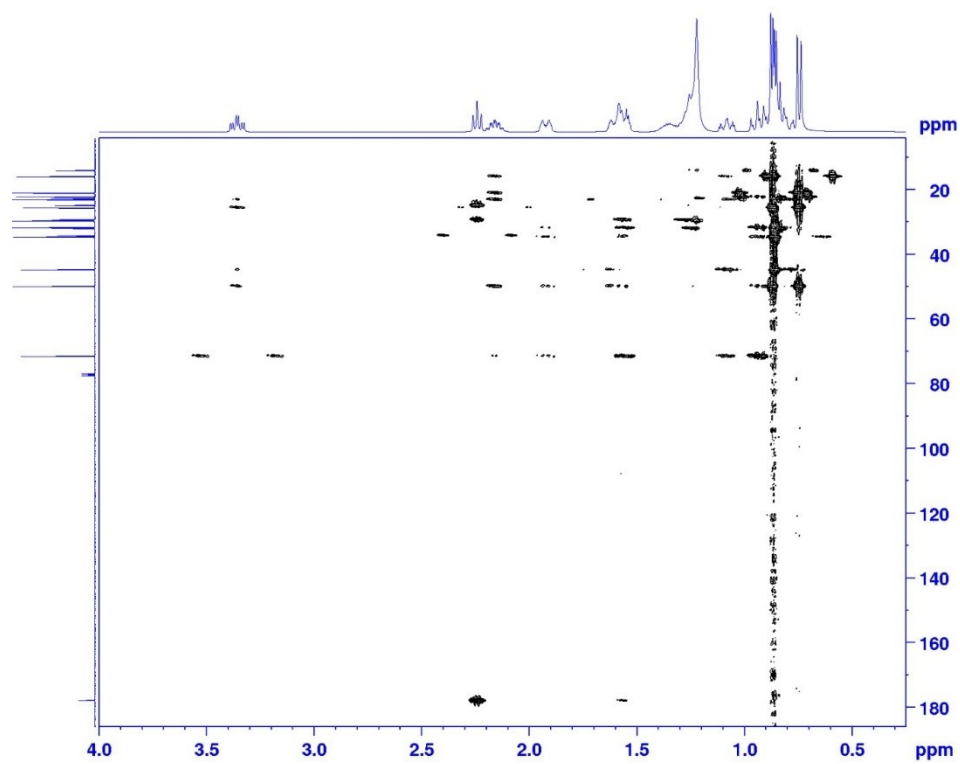
**Figure S7**  $^{13}\text{C-NMR}$  spectrum of l-menthol lauric acid DES in  $\text{CDCl}_3$ .



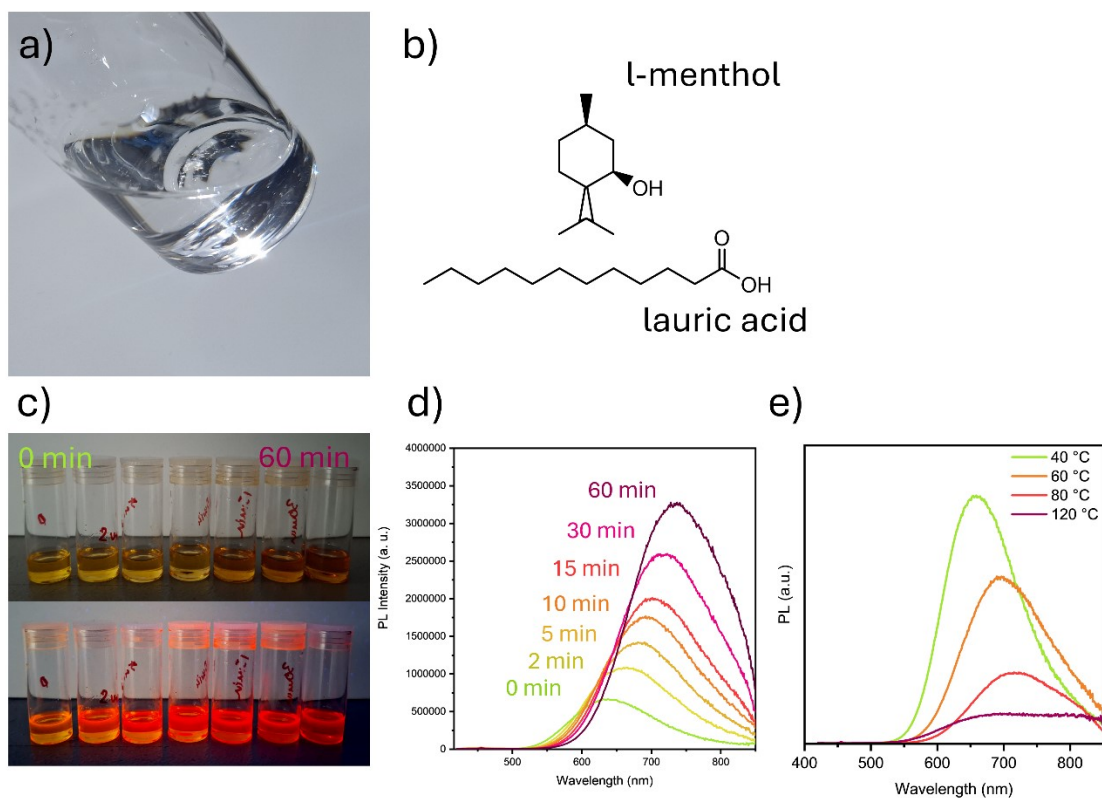
**Figure S8**  $^{13}\text{C}$ -DEPT-135 NMR spectrum of l-menthol lauric acid DES in  $\text{CDCl}_3$



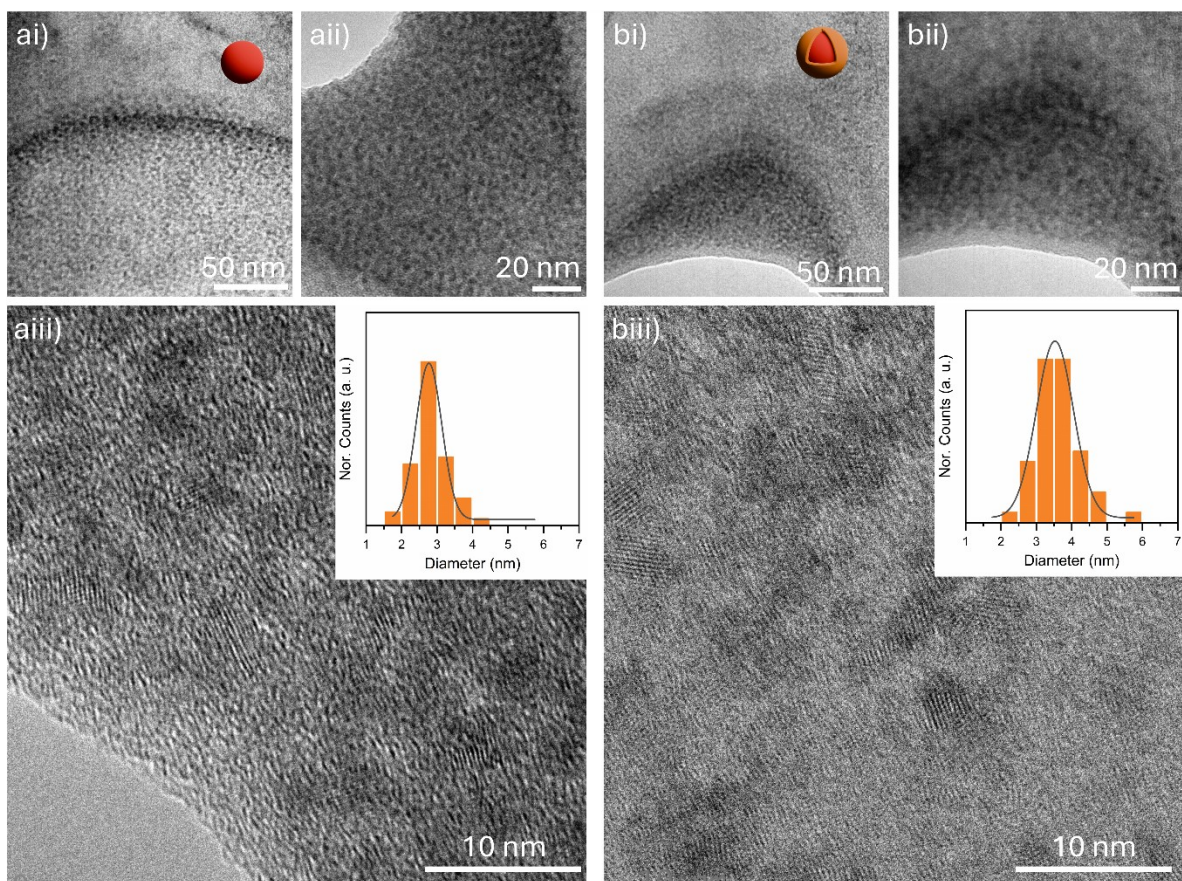
**Figure S9**  $^1\text{H}$ - $^{13}\text{C}$ -HSQC NMR of l-menthol lauric acid DES in  $\text{CDCl}_3$



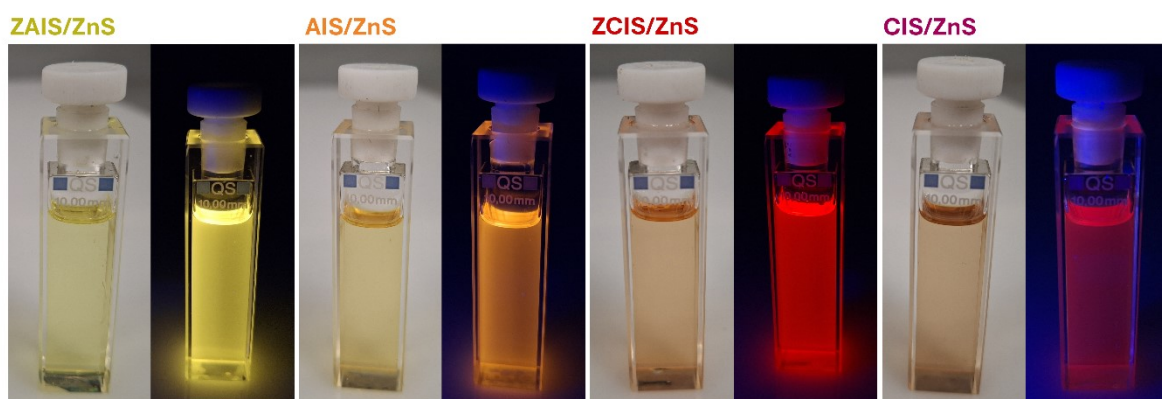
**Figure S10**  $^1\text{H}$ - $^{13}\text{C}$ -HMBC NMR of l-menthol lauric acid DES in  $\text{CDCl}_3$



**Figure S11** a) Photograph of the menthol-lauric acid DES at room temperature and schematic representation of the l-menthol and lauric acid (b). c) photographs of aliquots collected from the reaction mixture for the growth of AIS QDs at different reaction times at 120 °C, under ambient and UV light, and the respective PL spectra (d). e) PL spectra of AIS QDs growth, changing the temperature used for the sulfur injection step.



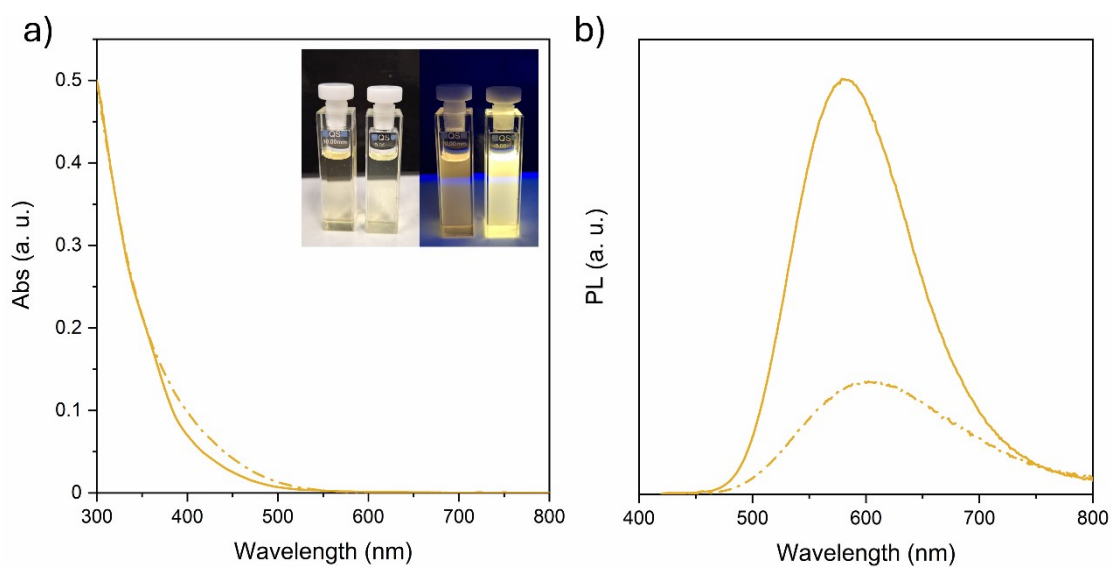
**Figure S12** TEM and HR-TEM images of ZAIS (ai-aii) and ZAIS/ZnS (bi-biii) multinary QDs produced in DES and their respective histograms of the particles size distributions (inset) based on 70 particles.



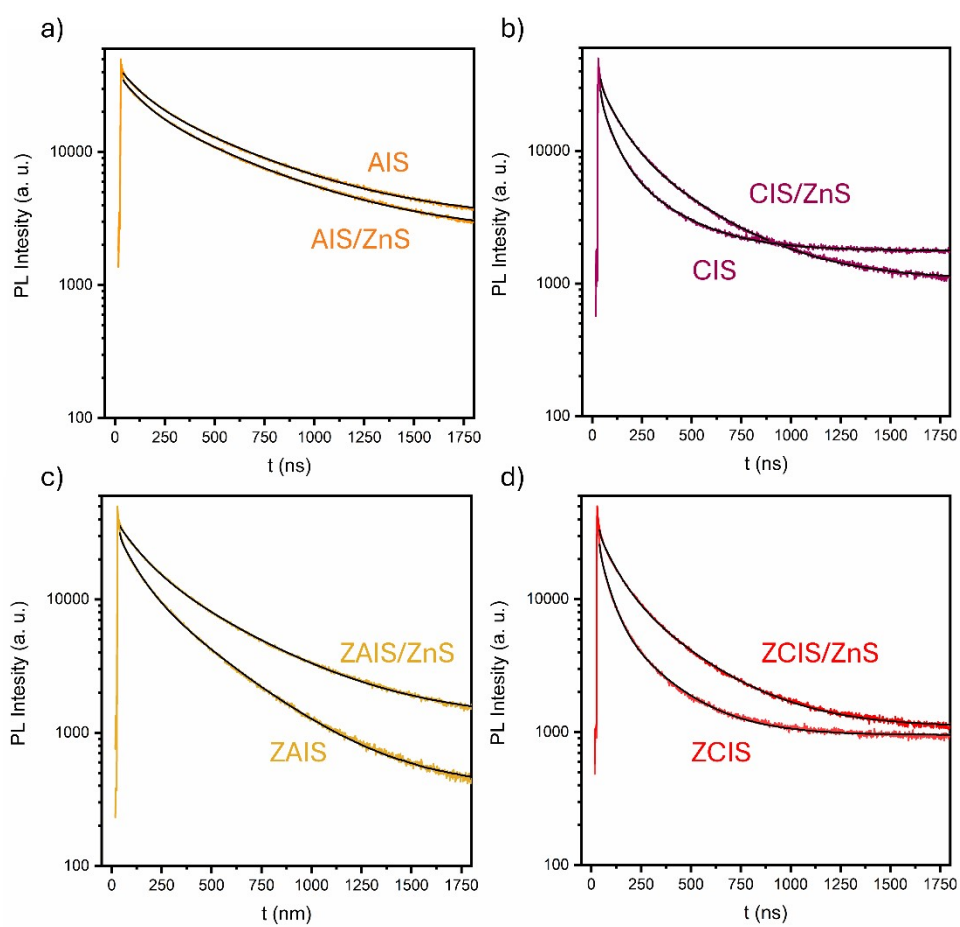
**Figure S13** Photographs of multinary core-shell QDs colloidal solution under ambient and UV light.

**Table 1** Summary of the optical properties of multinary core and core-shell QDs produced in the l-menthol lauric acid DES.

Multinary QDs	$\lambda_{\text{max}}$ (nm)	PLQY (%)	FWHM (nm)
AIS	658	14	137
ZAIS	595	18	159
CIS	705	10	124
ZCIS	690	16	122
AIS/ZnS	632	38	158
ZAIS/ZnS	581	65	121
CIS/ZnS	693	37	114
ZCIS/ZnS	655	44	109



**Figure S14** UV/Vis and absorption (a) and PL (b) of ZAIS (dashed line) and ZAIS/ZnS (solid line) QDs. Picture of ZAIS and ZAIS/ZnS QDs solution under ambient and UV light (inset).

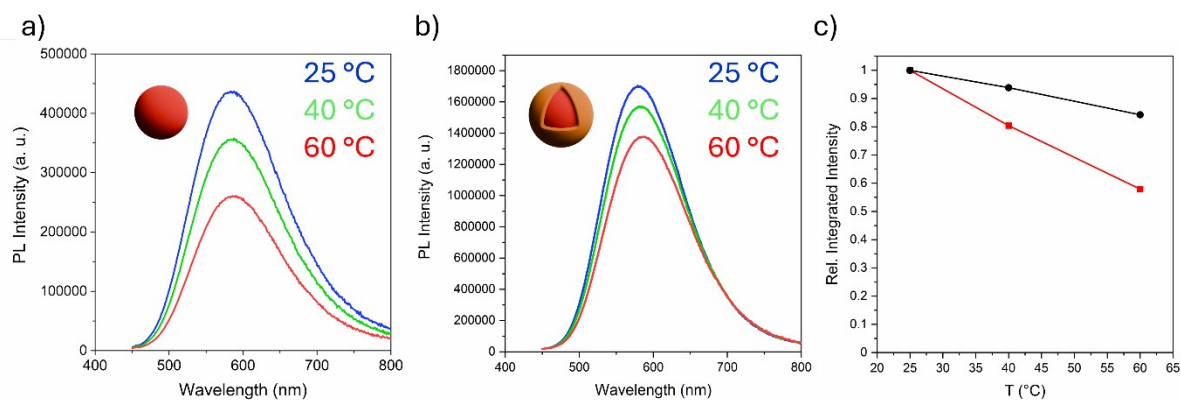


**Figure S15** photoluminescence decay measurements and two-exponential fitting of core and core-shell multinary QDs produced in DES.

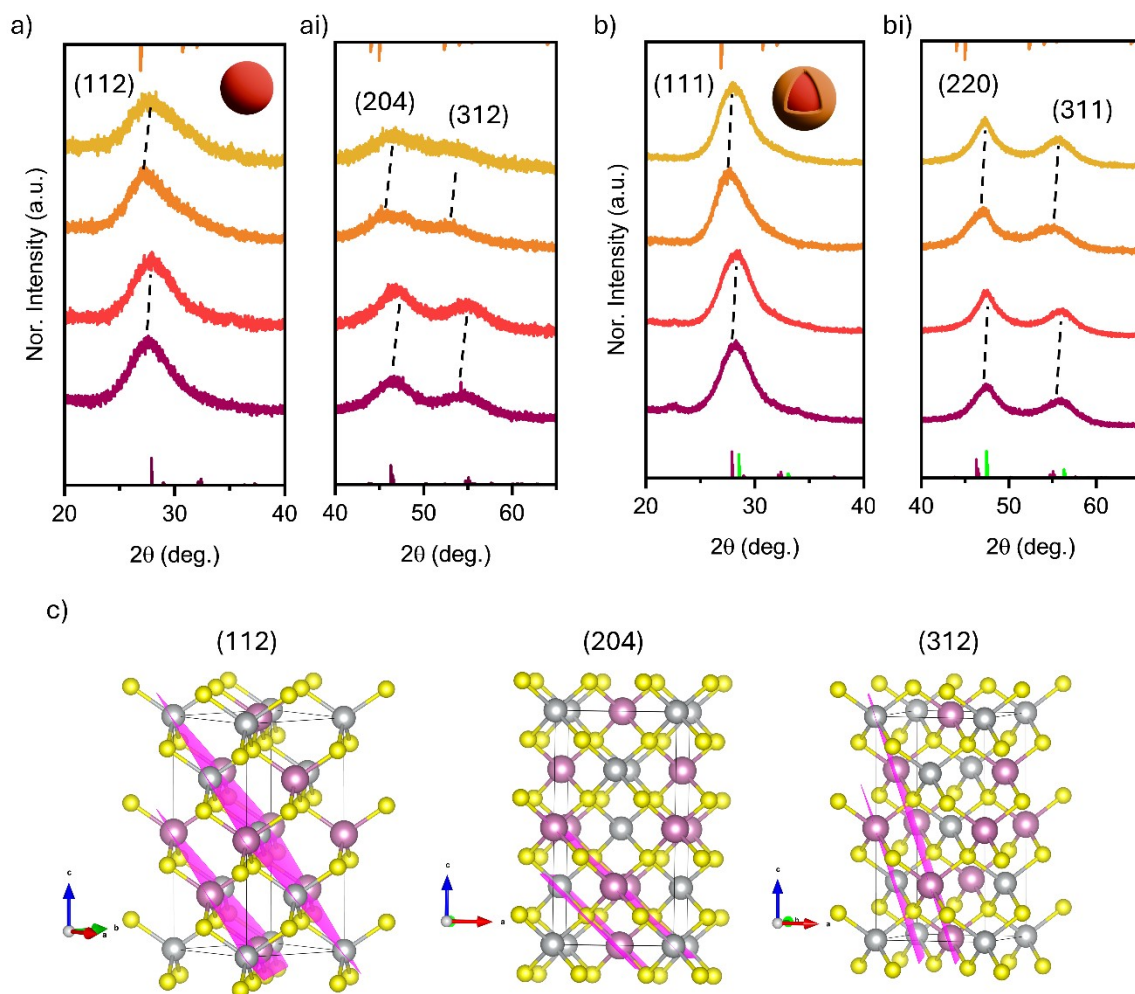
**Table 2:** detail of the photoluminescence lifetime analysis of multinary QDs at the PL maximum with a two-

Multinary QDs	$\tau_1$ ns	A1	$\tau_2$ ns	A2	$\langle\tau\rangle$ ns
AIS	81.1	8.67	489	91.33	483
ZAIS	50.6	15.93	311	84.07	303
CIS	26.5	22.87	191	77.13	184
ZCIS	25.5	27.94	182	72.06	174
AIS/ZnS	73.6	8.97	484	91.03	478
ZAIS/ZnS	85.5	14.59	404	85.41	393
CIS/ZnS	51.5	19.96	292	80.04	281
ZCIS/ZnS	45.6	17.92	268	82.08	360

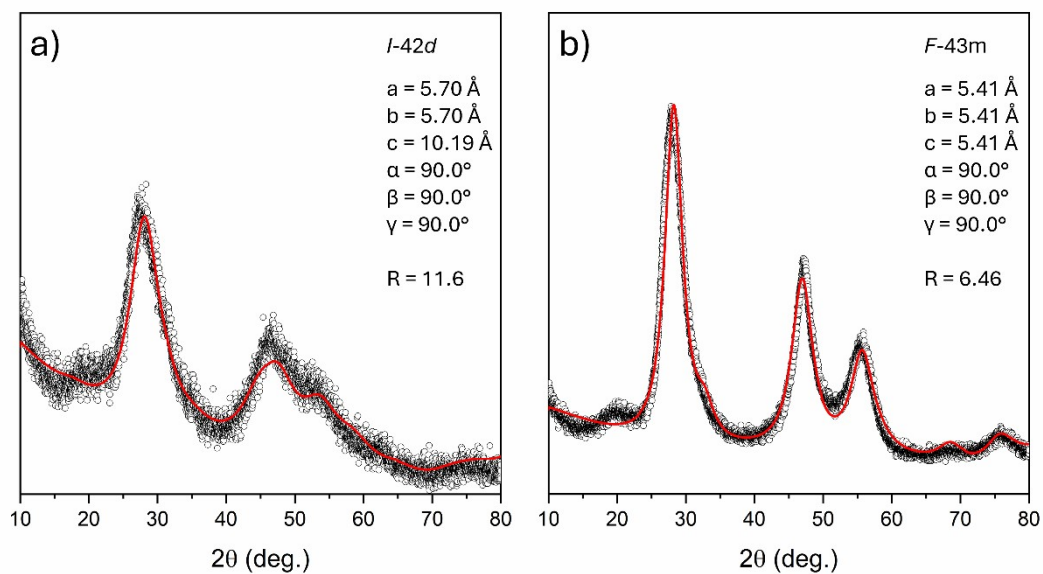
exponential decay model.



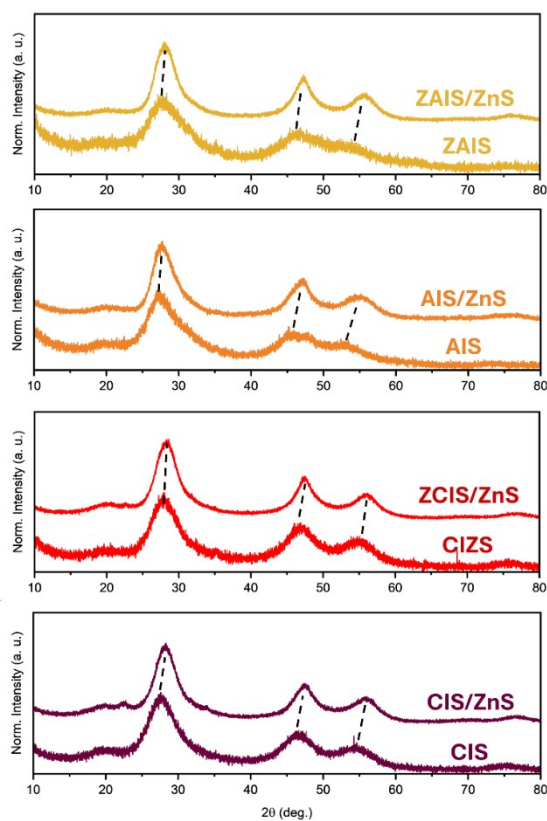
**Figure S16** PL of ZAIS (a) and ZAIS/ZnS (b) QDs at different temperatures. c) integrated photoluminescence intensity of ZAIS (square) and ZAIS/ZnS (circles) at different temperatures.



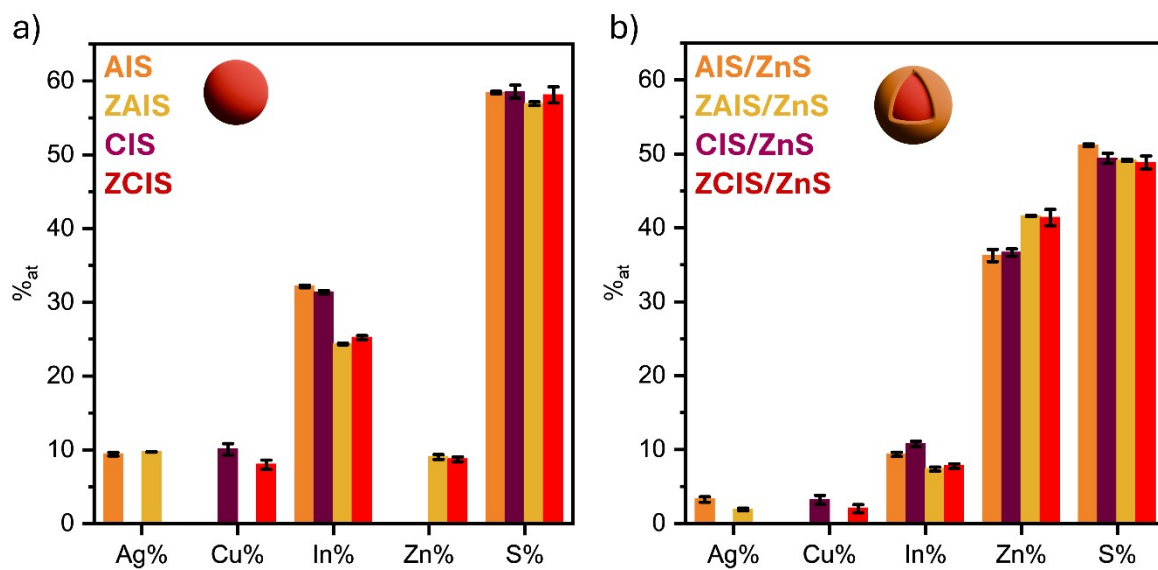
**Figure S17** Details of the XRD patterns of multinary core (a, ai) and core-shell (b, bi) QDs. Reference patterns used for XRD: AgInS<sub>2</sub> *I-42d* COD 1509400 (orange), CuInS<sub>2</sub> *I-42d* ICSD 66865 (wine) and ZnS *F-43m* COD 1100043 (green). c) representation of the discussed d-spacing in the chalcopyrite cell of AgInS<sub>2</sub>, colour coding: silver (grey), indium (pink) and sulfur (yellow).



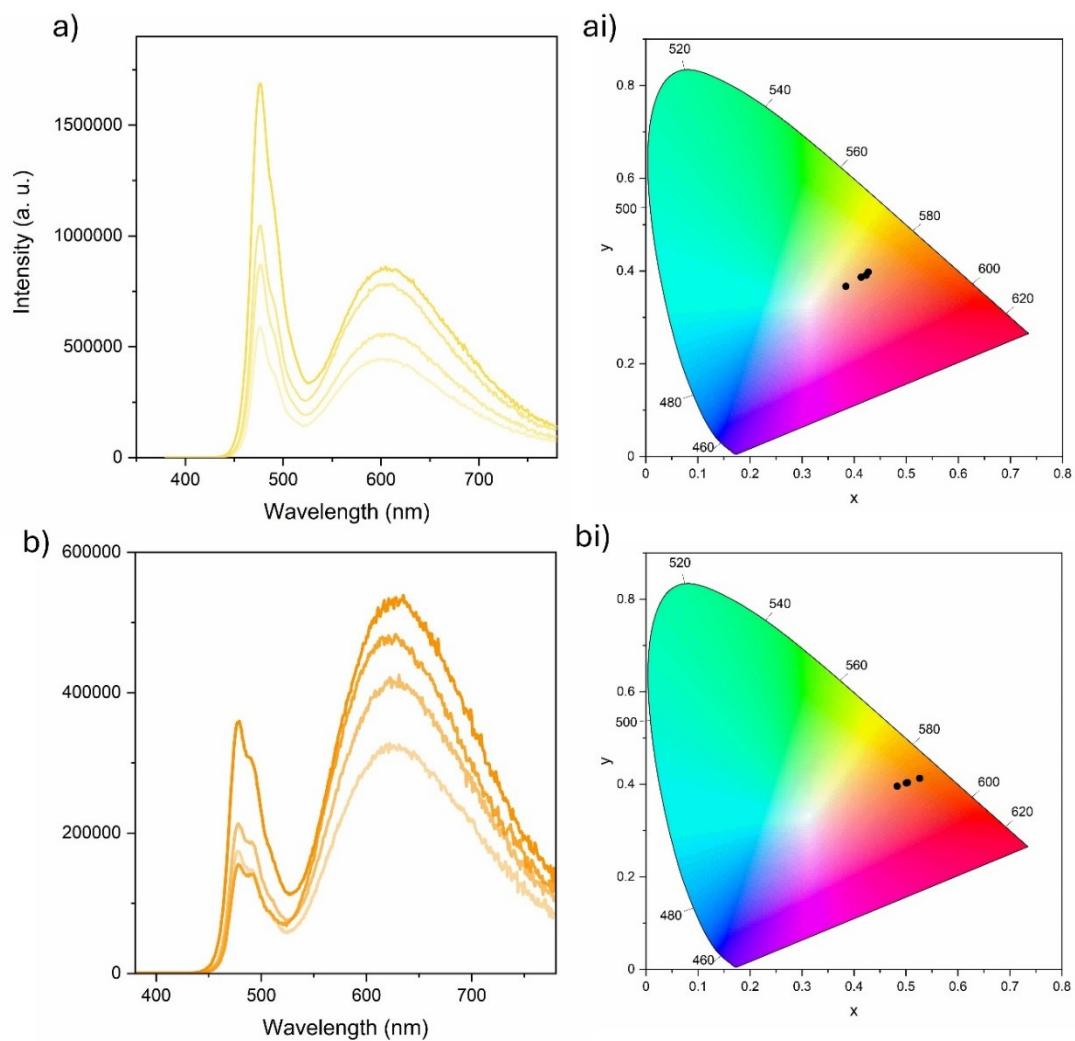
**Figure S18** Rietveld refinement of ZAIS (a) and ZAIS/ZnS (b) multinary QDs produced in l-menthol lauric acid DES.



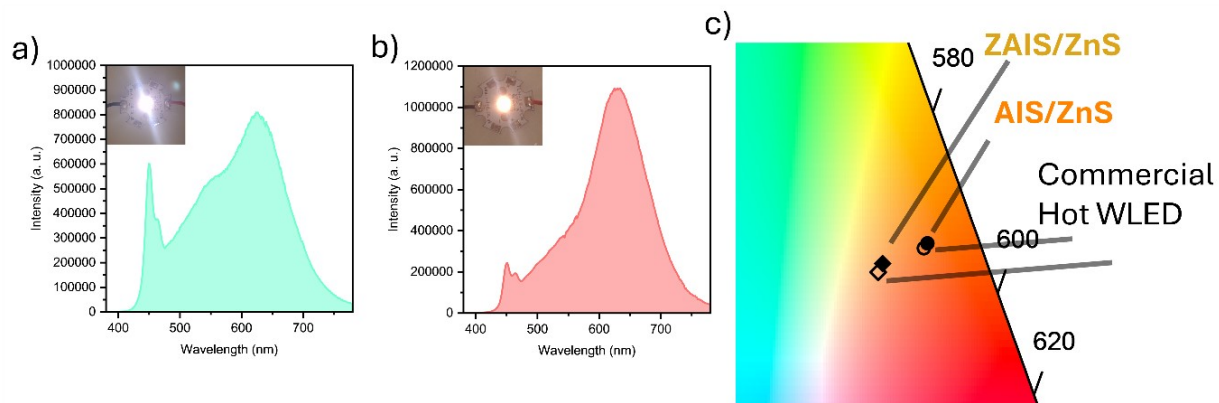
**Figure S19** Comparison between XRD patterns of core and core-shell of multinary QDs produced in l-menthol lauric acid DES.



**Figure S20** Results of the chemical composition analysis using EDS for multinary core (a) and core-shell (b) QDs produced using the l-menthol lauric acid DES.



**Figure S21** Luminescence spectra of white LEDs produced using ZAIS/ZnS (a) and AIS/ZnS (b) multinary QDs at 80, 100, 120 and 140 mA and (ai, bi) the corresponding CIE chromaticity coordinate diagrams.



**Figure S22** Comparison of the LED performance with commercial white LEDs. luminescence spectra of a white LED CRI 97 (a) and warm white LED CRI 92(b) at 100 mA, and detail of the CIE chromaticity coordinate diagram showing the coordinates of the multinary QDs and commercial LEDs.