New materials combining properties of liquid crystals and inorganic semiconductor quantum dots

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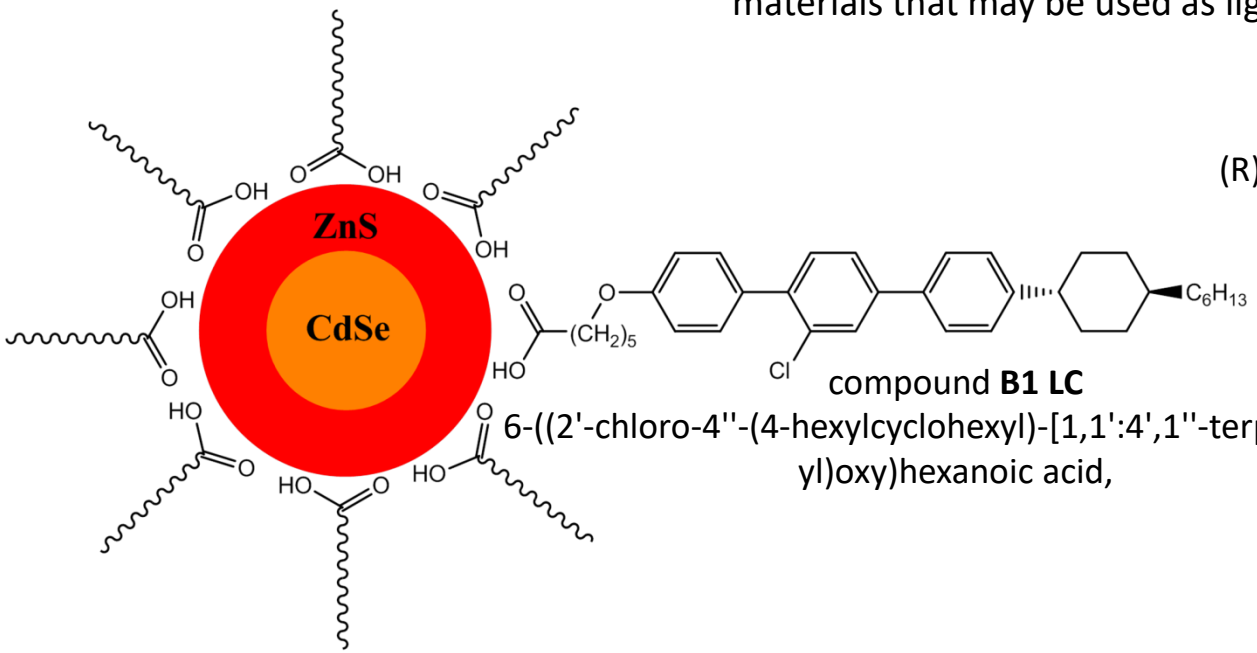
The **major goal** of this report is to present two newly synthesized LC materials that may be used as ligands for inorganic quantum dots

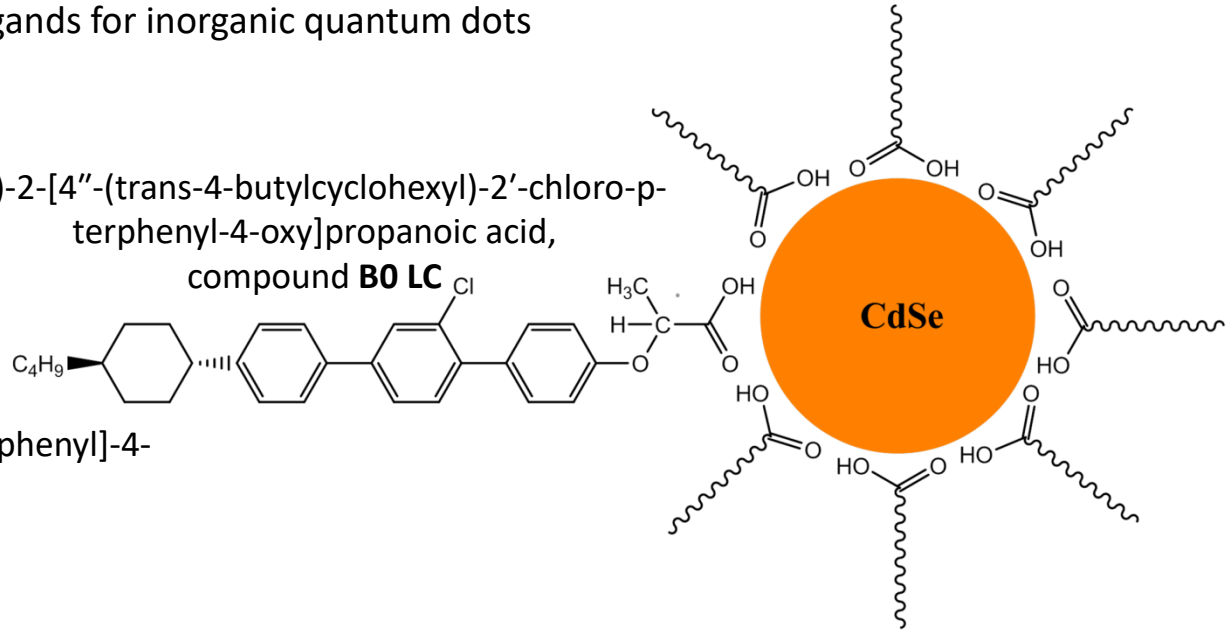


compound **B1 LC**

6-((2'-chloro-4''-(4-hexylcyclohexyl)-[1,1':4',1''-terphenyl]-4-yl)oxy)hexanoic acid,

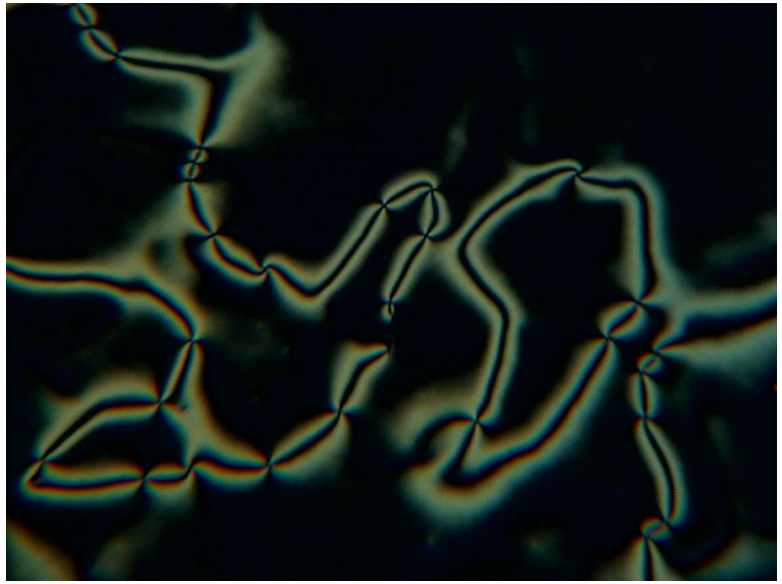
(R)-2-[4''-(trans-4-butylcyclohexyl)-2'-chloro-p-terphenyl-4-oxy]propanoic acid,

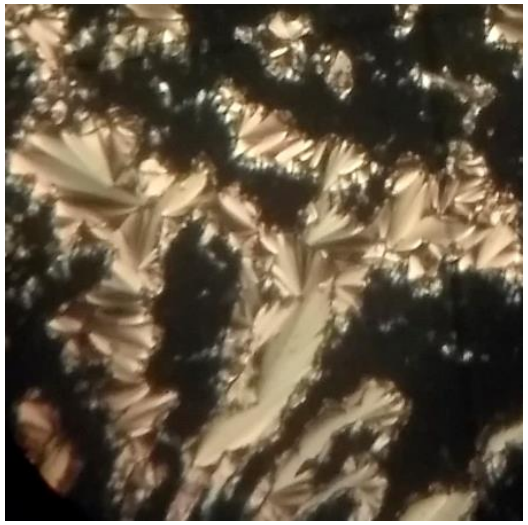
compound **B0 LC**



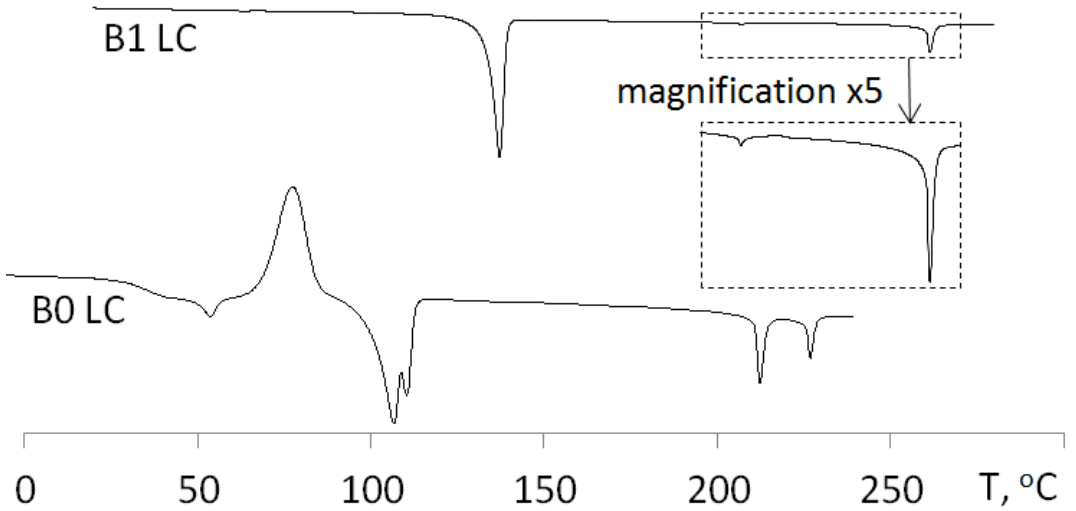
Properties of LC compounds

Nematic phase at 255 °C for B1 LC





Smectic (left) at 150 °C and chiral nematic (right) phase at 225 °C for B0 LC



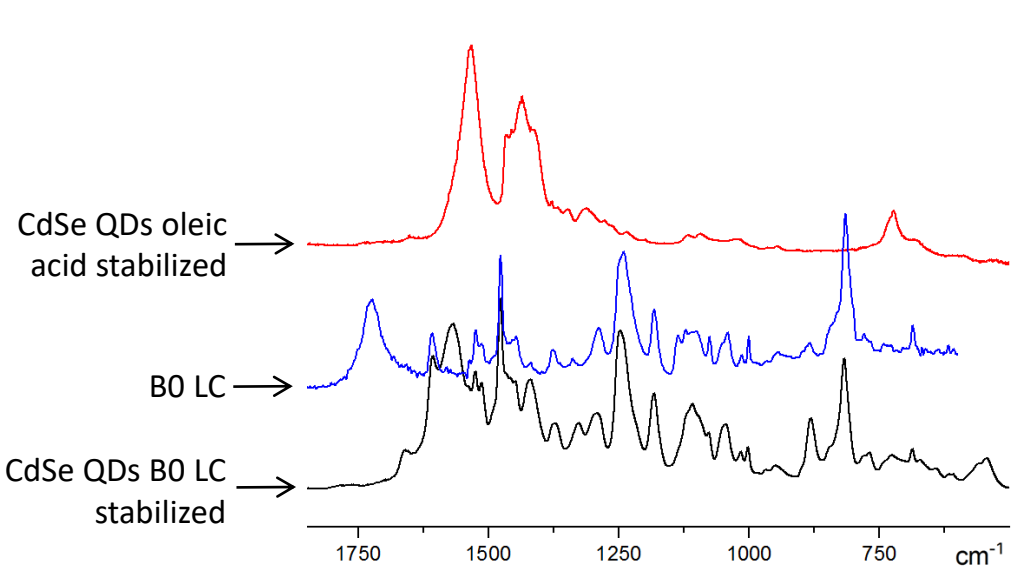
DSC curves above were used to examine thermal characteristics of liquid crystals. Crystalline **B01 LC** upon heating melts to homeotropic smectic phase (dark in crossed polarizers) at 137 °C followed by smectic – nematic transition at 207 °C and isotropization at 261 °C

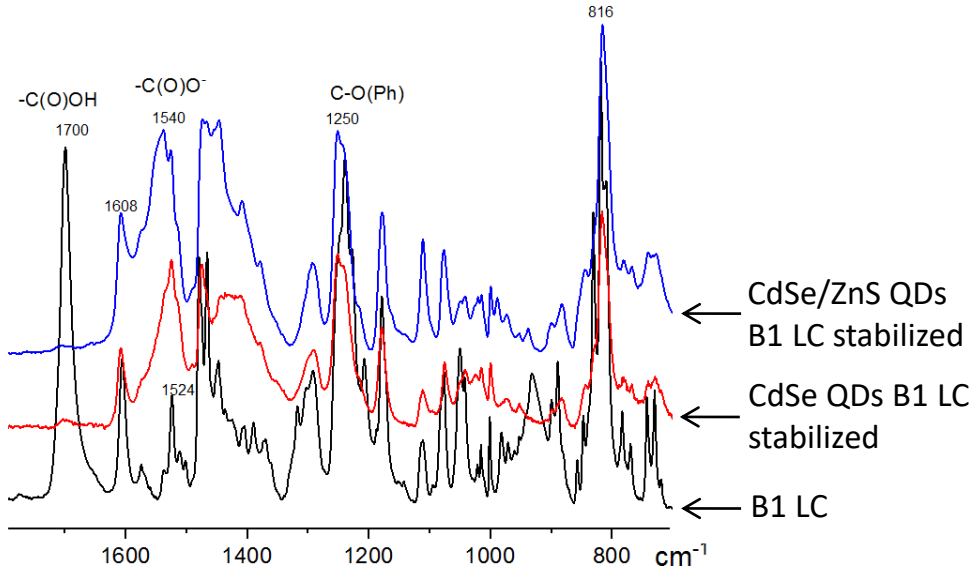
Upon heating **B0 LC** goes through the glass transition at 40°C followed by the crystal formation at 76 °C. Two melting peaks at 108 and 113°C correspond to crystal-crystal and crystal – LC transitions. Smectic LC formed at 113 °C is transformed into the chiral nematic phase above 213°C. The latter melts forming isotropic phase at 230°C.

LC-coated quantum dots

Ligand exchange reaction was applied to introduce COOH-functionalized LC compounds to the shell of quantum dots.
Fourier IR spectra below were used for the confirmation of QD – liquid crystal molecule interaction

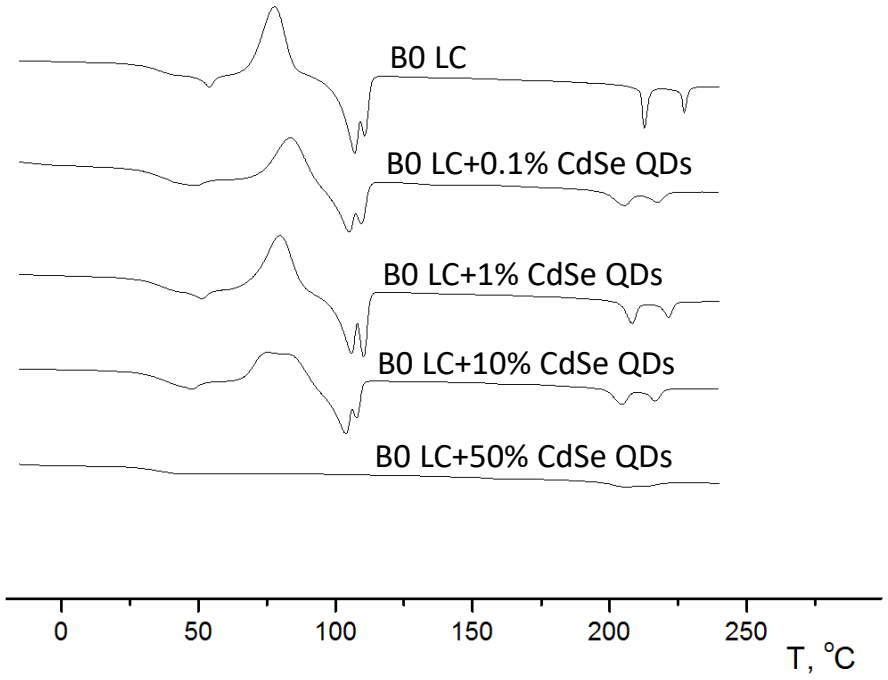
Core type CdSe QDs were coated by B0 LC and B1 LC
Core-shell type CdSe/ZnS QDs were coated by B1 LC



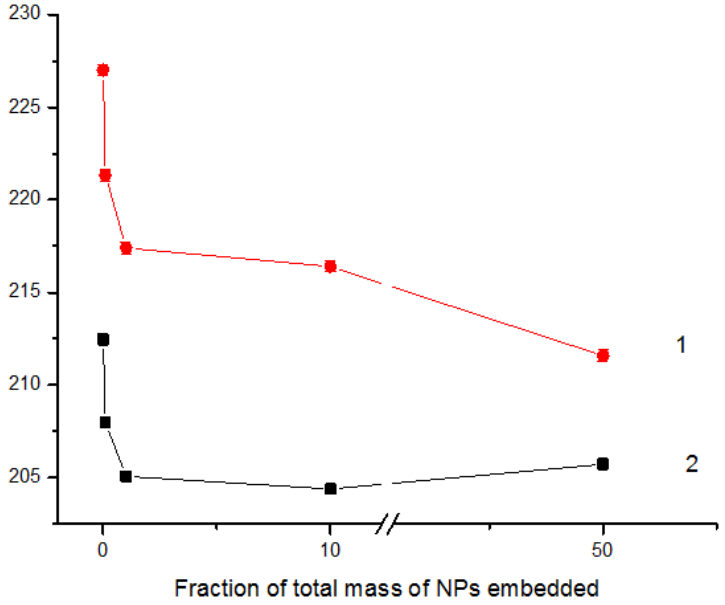


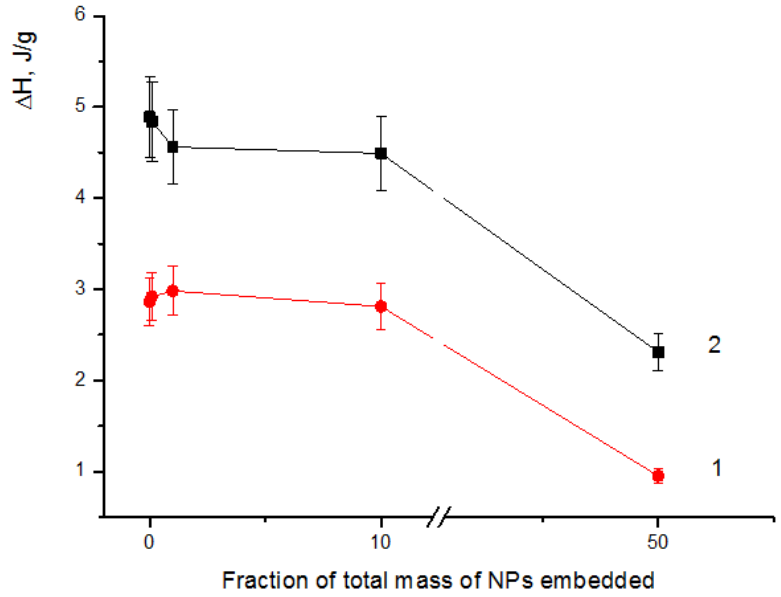
Disappearing of band at 1700 cm^{-1} for COOH group of LC compounds in composites of B0 LC and B1 LC with QDs means its transformation into COO^- form in the QD's shell. Other characteristic bands of LC compounds keep unchanged, so the ligand exchange reaction was completed

Thermal effect of QD concentration in B0 LC



DSC curves for B0 LC with CdSe QD





Transition temperatures (left) and enthalpies (right) of B0 LC varied with the change in the content of QDs in wt.% embedded into LC matrix :
1 - Chiral nematic-isotropic transition, 2 - Smectic-chiral nematic transition

Increasing concentration of QDs in B0 LC matrix leads to the decrease in chiral nematic-isotropic transition temperature which may be explained by the dilution effect consistent with the theory developed by Osipov and Gorkunov

Conclusions

Two newly synthesized liquid crystalline materials B0 LC and B1 LC bearing carboxylic functional group were characterized and introduced into the stabilizer shell of CdSe and CdSe/ZnS quantum dots via ligand exchange reaction

Presence of B0 LC and B1 LC in the QD shell was confirmed by Fourier-transform IR spectroscopy

Influence of QDs addition to the liquid crystalline state was observed