Optical anisotropy of superstructures from cadmium selenide quantum dots

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A development of new materials with the ability to control their properties is an urgent task in Material Science. One of the types of such materials are nanostructured materials, which are ordered assemblies of nanoscale structural elements. Superstructures, which are three-dimensional ordered assemblies of nanocrystals (or quantum dots, QDs) are called supercrystals. [1] The properties of these superstructures are unique in some way, as they combine properties either of individual QDs and of their ordered ensemble. Thus, by varying the parameters of initial structural elements, it becomes possible to obtain a superstructure with desired properties for further utilization as the active material in photovoltaic devices, electronics and other fields. [2]

In this work we have studied the polarization in transmission of superstructures formed by self-organization of CdSe QDs of different sizes on the dielectric substrates, depending on the type of ligand and QD size.

Colloidal CdSe-core QDs with diameters of 2.1 and 3.1 nm were used. Initial CdSe QDs were coated by trioctylphosphine oxide (TOPO) molecules. They have been replaced by oleic, stearic acid, oleylamine and dodecanethiol. A successful procedure for ligand replacing have been confirmed by FTIR-analysis. The obtained QD colloidal solutions were used for the preparation of superstructures on a slide glass. QD colloidal solution has been dripped onto substrate from 3 to 5 times.

It has been found that the position of the absorption and luminescence band depends on the type of an organic molecule on the surface of the QD: the largest shift has been observed for the QD/oleic acid superstructures. The morphology of the obtained QD superstructures strongly depends on the type of the molecule on the QD surface. For instance, a superstructure formed by QD/TOPO represents dendritic structures, the shape of which is similar to the structures formed by TOPO molecules themselves (Fig.1 (a) and (d)).

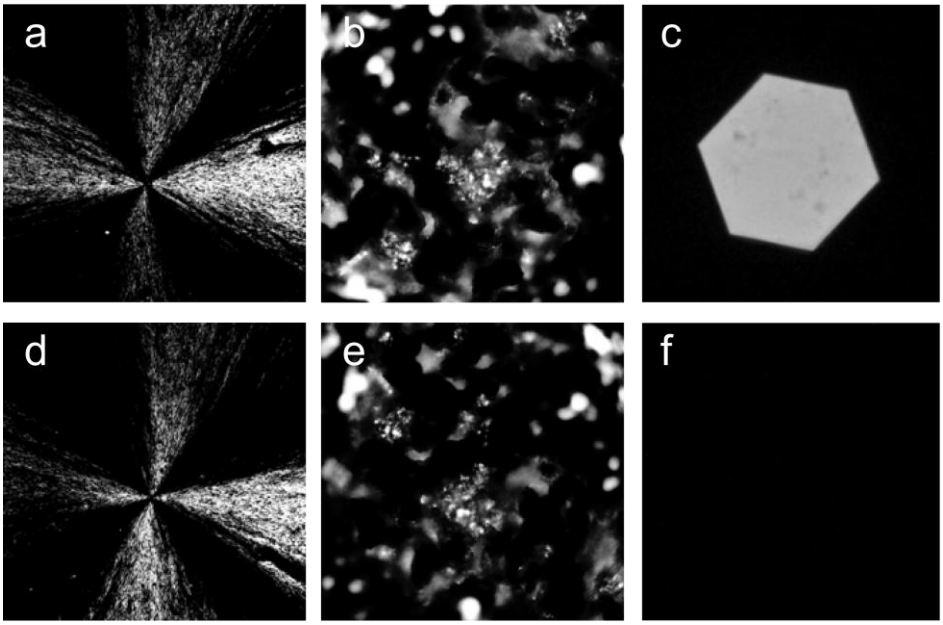

Fig. 1 Microphotographs of transmission of samples with suprestructures formed by QDs in polarized light (crossed polarizers geometry): (a) and (d) - TOPO, (b) and (e) – stearic acid, (c) and (f) – oleic acid. Rotating angle: (a)-(c) – 0 deg, (d)-(f) – 45 deg.

Investigation of the polarization properties of the samples also reveals that they are strongly dependent on the superstructure morphology, and, therefore, depend on the type of ligand. Figure 1 shows the microphotographs in polarized light for the samples of superstructures formed by 3.1 nm QDs. We conclude that the organic molecules on QD surface control the morphology of superstructures formed and, hence, may change the optical properties, including polarization of the light transmitted through the structure.

1) M. A. Boles et al., *Chem. Rev.*, **2016**, *116*, 11220.
2) C. R. Kagan et al., Science, **2016**, *353*, aac5523.