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PhD thesis summary

Liquid crystalline DNA doped with nanostructures

The main topic of this PhD thesis is related to liquid crystals doped with gold nanoparticles. Combining the unique properties of gold nanoparticles with the ability of liquid crystals to self-organize might be beneficial for improvement/enhancement of liquid crystal properties and possibility of liquid crystals application as a matrix which provides the platform for nanoparticles ordering. Lyotropic DNA liquid crystals and gold nanoparticles of different shape and size are basic materials described within this dissertation.

The PhD thesis begins with the presentation of the study motivation and research goals, which were 1) to analyze whether DNA liquid crystal self-assembly has a direct influence on the local spatial conformation of single DNA molecules forming the liquid crystalline phase, in the context of DNA liquid crystal observation *in vivo*, and 2) to characterize the properties of DNA liquid crystals doped with silver-doped gold nanoclusters, gold nanorods and gold nanostars. The most important information about DNA, its organization both *in vivo* and *in vitro*, about gold nanoparticles, their linear and nonlinear optical properties and about liquid crystal – gold nanoparticles systems is presented in the Introduction part. The next chapter describes the most important experimental methods, which were used to characterize prepared samples and were the source of the data analyzed within this dissertation (polarized light microscopy, photochemical analysis of structural transition and two-photon excitation fluorescence microscopy).

The experimental part of the PhD thesis consists of four chapters, which describe and discuss the obtained results. The first chapter concerns the application of biochemical techniques for the investigation of DNA liquid crystals, which enabled to accomplish the first research goal. DNA liquid crystal *in vitro* was used as a simplified model of DNA organization *in vivo* and the application of photochemical analysis of structural transition method showed that liquid crystalline ordering of DNA leads to essential structural changes in the local spatial conformation of DNA molecules. The influence of pH and the presence of

Na^+ and Mg^{2+} on the local spatial structure of DNA in solution and liquid crystal were also tested. It was observed that local groove architecture is not only dependent on the level of DNA molecules organization, but depends also on the experimental conditions (concentration of appropriate metal ions and pH).

The next chapters describe properties of DNA liquid crystals doped with differently shaped and sized gold nanoparticles. Prepared samples were characterized with the microscopic techniques mentioned previously. The type and order of DNA liquid crystalline phase formation was preserved in all samples, regardless of the amount and type of dopant used. In the case of DNA liquid crystals doped with silver-doped gold nanoclusters, it was observed that the level of DNA molecules ordering and mechanism leading to the formation of liquid crystalline phase play an important role in the processes of nanoclusters distribution and aggregation within DNA liquid crystalline phase. The comparison of DNA liquid crystals doped with positively and negatively charged gold nanorods, showed that the interaction between negatively charged DNA and positively or negatively charged ligands present on the surface of nanoparticles may lead to thermal stabilization or destabilization of liquid crystals. The observation of DNA liquid crystals doped with gold nanostars indicated that liquid crystalline DNA cannot serve as a matrix providing the ordering of this type of gold nanoparticles. However, research on DNA liquid crystal – gold nanostars systems may be useful in the context of possible gold nanostars application in two-photon imaging.

In conclusion, it was shown that the introduction of gold nanoparticles into DNA liquid crystals, depending on the shape and size of nanoparticles and ligand present on their surface, may lead to an increase or decrease of thermal stability of liquid crystals and an increase or decrease of cholesteric pitch. Dispersing nanoparticles in liquid crystals offers a simple and effective method for modification of the properties of liquid crystals. Thanks to linear and nonlinear optical properties of nanoparticles it was possible to determine the distribution of nanoparticles in DNA liquid crystals. Nanoparticles preserve their optical properties in the presence of liquid crystalline DNA. It indicates their potential in bioimaging applications.