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Non-linear optical properties of organometallic assemblies for biophotonic applications

Short Summary

The hypothesis of this research project is that novel developments both in materials science and in chemistry can be made by combining unique properties of certain DNA structures with the nano-cage like organometallic molecules to obtain new photonic nano-assemblies addressable by two-photon excitation. At the same time the biological activity (interactions with various forms of DNA) of the new organometallic molecules will be check by the means of linear and non-linear optics. We propose an interdisciplinary effort, where the physical properties of the organometallic molecules arranged into nano-assemblies on the DNA scaffold are engineered to obtain their optimal combination for a given medical or photonic application. DNA from the viewpoint of materials science can be regarded as an excellent nanomaterial, which is in part due to the fact that it can adopt well-defined 3D helical architectures at macro- and supramolecular level. In fact, the helical arrangement can serve as excellent scaffold e.g. for assembling chromophores or nanoparticles with applications as artificial photoresponsive programmed systems. Besides the fundamental role of genomic ds-DNA in genetic information storage, expression, replication and transmission, there is growing evidence that other non-canonical forms of DNA structures also play major regulation roles in the cell life cycle and metabolism hence the need of the molecules effectively interacting with such structures which could stop the misfolding of the DNA and G-quadruplex formation as their replication-induced shortening is responsible for the regulation of cell death. We propose to explore the non-linear optical properties of assemblies of the canonical and non-canonical forms of DNA with organometallic molecules also in the context of the quest for the best G-quadruplex binders. The proposed project focuses on investigations of novel NLO materials that exhibit enhanced nonlinear absorption because this particular NLO property has found the most applications to date. In recent years, the Wroclaw group has been concentrating on biological implications of the multiphoton processes, e.g. for nonlinear microscopy, for detection and stabilization of the DNA strands and its non-canonical structures such as G-quadruplex both in diluted solutions and in the liquid crystal phases, for theranostic applications involving light-activated therapies such as photodynamic therapy etc. It is expected that a number of different nano-assemblies based on metal-organic frames and showing promise as nonlinear absorbers will be synthesized in the laboratory in Neuchatel, which is well equipped for such work, with contributions from Wroclaw participants, and the NLO potential of such structures will be assessed in a joint effort, the suitable equipment for NLO characterization being available in Wroclaw. The synergy of the collaborating groups will be exploited by intensive exchange of personnel, especially young researchers: PhD students and postdocs. The aims of the project include also reliable determination of figures of merit of all materials as well as proof-of-concept demonstrations of their suitability for proposed applications in photonics, biophotonics and possibly in medicine. In addition, this project might provide us with the possibilities for testing/screening of the nano-cages bound to DNA, and for their NLO performances in the form of DNA-nano-assembled structures. Furthermore, once identified as promising targets for a given application, developing an efficient, cheap and versatile synthetic access toward a new class of organometallic nano-assemblies will also constitute an objective of the synthetic team.