Synthesis of the analogues of diketopyrrolopyrroles displaying high two-photon absorption cross-sections

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The main goal of the PhD-thesis was to synthesize polar dyes based on the diketopyrrolopyrrole (DPP) core, showing high values of two-photon absorption cross-sections (σ_2) and good fluorescence quantum yields (Φ_{fl}), suitable for the applications in two-photon fluorescence microscopy (TPFM).

A series of polar DPP derivatives, mainly possessing quadrupolar donor-acceptor-donor chromophores, were designed and synthesized. The introduction of polar functional groups (ionic and non-ionic) allowed for the preparation of strongly fluorescent dyes which show good solubility in polar solvents. Some of obtained derivatives are highly soluble also in water and their aqueous solutions exhibit high fluorescence quantum yields. It was demonstrated, that two polar dyes based on DPP can be applied in the fluorescence microscopy for the selective staining of the cell nucleus.

The methodology for the synthesis of structurally unique π-expanded diketopyrrolopyrroles (EDPP) was also developed. EDPP are planar derivatives of DPP, bearing two additional six-membered rings between the aromatic substituents at 3 and 6 positions, and the DPP heterocyclic core. The two-steps route of EDPP synthesis consists of the *N*-alkylation of DPP with bromoacetaldehyde acetal or α-bromoketone and subsequent acidic cyclization of the obtained intermediate. EDPP dyes are characterized with unusually strong one-photon absorption (molar absorption coefficients up to 200 thousands units), high fluorescence quantum yields (Φ_{fl} = 70–99%), and small Stokes shifts (<10 nm).

Many of the obtained DPP derivatives, polar, as well as non-polar (EDPP, DPP diacetals), show very high values of two-photon absorption cross-sections (~2000–4500 GM). Due to high fluorescence quantum yields, for some of these compounds remarkably high values of two-photon brightness were achieved (>1000 GM), which makes them promising dyes for applications in two-photon imaging techniques.