MSc. Adam Szukalski
Chemistry Department, Wroclaw University of Technology
Wybrzeże Wyspiańskiego 27 st., 50-320 Wrocław
Advanced Materials Engineering and Modelling Group
building: A-3 /room: 401 b
telephone number: (71) 320-23-17
e-mail address: adam.szukalski@pwr.edu.pl

Wrocław, 22nd of June, 2016

SUMMARY OF THE DOCTORAL DISSERTATION

Investigation of nonlinear optical and luminescent properties of the selected pyrazoline derivatives

The doctoral dissertation, titled: " *Investigation of nonlinear optical and luminescent properties of the selected pyrazoline derivatives*", has been realized in Advanced Materials Engineering and Modelling Group in Chemistry Department at Wroclaw University of Technology, under the supervision of prof. Jarosław Myśliwiec. The aim of this work was to optical characterization of the selected pyrazoline derivatives in few fields: luminescent properties (also light amplification by stimulated emission or random lasing) and also 2^{nd} and 3^{rd} order of the nonlinear optical properties (multiphoton absorption, generation harmonics of light and also photoinduced birefringence).

The doctoral dissertation contains basic characterization of chemical structure of the investigated compounds, include calculated and defined crystal structure in singular cell (X-ray spectroscopy of monocrystals; calculations and analysis were done in Polish Academy of Science located in Wrocław) and also detection of particular oscillations from characteristic groups of atoms or moieties (IR spectroscopy, Chemistry Department at the University of Wroclaw). Moreover, the spectroscopic characterization was done for the new luminescent molecules by measurements of absorption and fluorescence spectra in organic solutions (THF), but also in polymeric thin films (PMMA).

Furthermore, the light amplification phenomena in polymeric hybrid systems doped by nonlinear chromophores, have been characterized. Stimulated emission (SE)/amplified

spontaneous emission (ASE) and random lasing (RL) have been investigated. During the RL measurements the Variable Stripe Length method (VSL) according to surface of the excitation laser beam, was used. Nanosecond laser pulses were used as the incident light. Investigated features: energy threshold for obtaining SE/ASE or RL, system photostability and other spectroscopy parameters, like: Full Width at Half Maximum (FWHM) of emission band, its shape and location in the wavelength range. Also particular features due to the optical resonators have been investigated in the context of random lasing.

Moreover, for the thin polymeric films also measurements in the field of second (SHG) and third (THG) harmonic generation phenomena have been investigated, likewise for various dye concentration. Based on this, the 2nd and 3rd order nonlinear optical susceptibilities have been defined - $\chi^{(2)}$ i $\chi^{(3)}$. During the measurements, picosecond pulsed laser and Maker fringes technique, were used. All of these investigations were done at the University in Angers (France), which were realized in the ETIUDA project, funded by Polish National Science Center.

Furthermore, the photoinduced anisotropy of refractive index in the Optical Kerr Effect phenomenon was investigated. Photoinduced optical birefringence (Δn), but also value of nonlinear refractive index (n_2), Kerr constant (B) and other parameters describing photoinduced conformational transformations $trans - cis - trans$, have been characterized. Moreover, thanks to the cooperation with University of Wroclaw and Polish Academy of Science in Warsaw, the series of quantum chemical calculations due to the mechanism of conformational changes in pyrazoline derivatives based systems, but also values of the dipole moments, were done and described.

In cooperation with prof. Marek Samoć grup, the Two Photon Absorption (TPA) and Three Photon Absorption (3PA) phenomena have been investigated. During the experiments, the femtosecond laser light and z-scan technique were used. Based on these measurements the profile of nonlinear absorption parameters (σ_2 and σ_3) for the TPA and 3PA were defined.

Furthermore, the doctoral dissertation includes experimental results obtained in University of Salento (Italy) and CNR-Nano Institute in Lecce (Italy). The electrospun micro- and nanofibers based on the pyrazoline derivatives, which doped deoxyrybonucleic acid (DNA) functionalized by CTMA surfactant were prepared and therefore investigated by the SEM microscope and confocal system to characterize their morphology and prove waveguide abilities. Moreover, it was proven the refractive index modulations fully controlled by light, which gave the conclusion that these kind of materials can be used for construction of the ultrafast optical modulators or efficient optical memories.