New polymethine nonlinear optical medium for diode-pumped Nd:YAG laser systems

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The main goal of this work was development of the material with high absorption band at the Nd:YAG lasing wavelength λ_l = 1064 nm and at the same time with extremely low absorption at the wavelength of the laser diode pump radiation λ_p = 808 nm. Such material enables a fabrication of the nonlinear/bleaching structures as well as the special coatings for Nd-containing active elements offering a possibility of an improvement of their energy and spatial characteristics [1].

[1] *T.V. Bezyazychnaya et.al. Transversally diode-pumped Q-switched Nd:YAG laser with improved power and spatial characteristics // Opt. Communications. – 2013. – vol. 208.– p.26–29.*

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The two-absorption band (1064 and 808 nm) thiopyrylo-4-tricarbocyanine dye **1** has been proposed and synthesized in the Institute of Organic Chemistry, National Academy of Sciences of Ukraine [2], see Fig. 1.

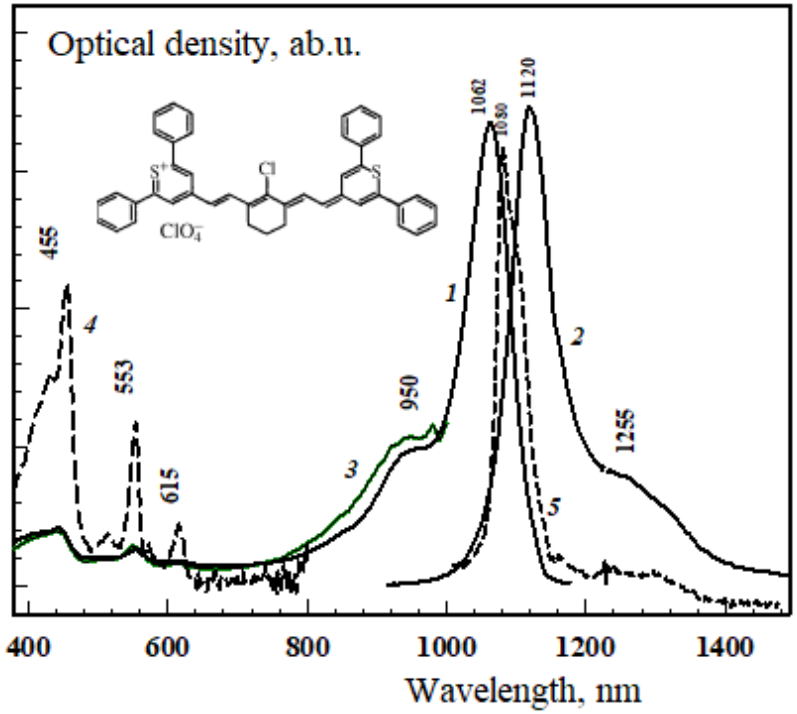

Figure 1: Spectra of absorption (1), fluorescence (2,5) and the fluorescence excitation (3,4) for the developed polymethine day **1** in the methylene chloride at 293 (1-3) and 77 K (4,5). The insert shows the molecular structure of the dye **1**.

[2] A.A. Ishchenko et. al. Electronic structure and spectral-fluorescent properties of laser thiopyrylo-4-tricarbocyanine dyes // Optics and Spectroscopy. – 2021. – vol. 129, No. 7. – p. 862 – 870.

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The dye developed has the highest value of the absorption cross-section at λ_I among the organic dyes and it is quite transparent within the spectral interval 800–900 nm. The dye **1** has considerable solubility in a number of known polar solvents. This allows formation of highly concentrated solutions and solid films with optical parameters suitable for the application in the Nd:YAG diode-pumped laser systems.

It is important that the electronic and steric structure of the dye **1** minimizes the formation of aggregates at high concentrations in thin films. As a result, the absorption spectrum of dye **1** in the polyvinyl butyral film has the same band profile as in dichloromethane. Therefore, a highly efficient polymer passive Q-switch elements based on it have been created.

Nonlinear optical properties of the dye **1** polymer thin films were examined in the experiments with the nanosecond Nd:YAG (transversal diode pump, passive Q–switch unit based on the dye **1** film) and picosecond Nd:YVO_4 (longitudinal diode pump, the dye **1** film in the form of the saturable absorber mirror structure) laser systems. The monopulse regimes with the laser pulse duration of 30 ns in first case and 10 ps (the pulse train with the pulse repetition rate of ~ 100 MHz) in the second one were realized.

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