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PULSED LASERS AND LASER APPLICATIONS

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B-9

INVESTIGATION OF PHOTONICS OF DIPYRROMETHENE COMPLEXES TO CREATE OPTICAL MATERIALS BASED ON THEM

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Currently, the direction of photonics is actively developing, associated with the creation of optical materials and functional devices based on complex organic compounds. Information on the relationship between the structure of such compounds and properties allows one to formulate the scientific foundations for creating optical devices: active laser media, media for organic light-emitting devices, laser limiters, and optical sensors.

The spectroscopic and photochemical properties of dipyrromethene complexes in the ground and excited electronic states were studied. The results indicate the possibility of creating active laser media with a high lasing efficiency based on BF_2-dipyrromethenates. Binuclear bis (dipyrromethenates) exhibit a temperature dependence of the fluorescence intensity, which can be used in the development of optical sensors for determining temperatures in the range of 300-80K. The halogenated complexes of dipyrromethenes are characterized by the presence of phosphorescence with a high constant of quenching of triplets by oxygen. The presence of a straight-line dependence of the phosphorescence intensity on the oxygen concentration, high sensitivity, and fast response time – all this confirms the promise of creating an optical oxygen sensor based on halogen substituted dipyrromethenes.

The results were obtained within the framework of the State Assignment of the Ministry of Education and Science of the Russian Federation, Project No. FSWM-2020-0033.

B-10

PHOTOPHYSICS OF 1,4-DIAZINE BASED D-(π)-A PUSH-PULL MOLECULAR SYSTEMS

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Organic molecules, which emit light in the field of applied voltage, have been widely used to create organic light-emitting diodes (OLEDs) in recent decades. Currently, screens of mobile phones, tablets, television sets, and on-board car computers are manufactured using OLEDs. Along with the obvious advantages of organic LEDs, such as high contrast and brightness, the ability to create devices on the flexible base surface and relative ease of manufacturing, there are a number of problems that scientists continue to work on. One of them is low internal quantum efficiency. It is related to the formation characteristics of light emitting centres in the OLED structure during electroexcitation. According to quantum statistics, 75% of the created excitons are in the triplet state and only 25% are in the singlet. It is known that the triplet state of most organic molecules is non-radiative, especially at room temperature. The exception is metal organic complexes based on precious metals, such as iridium. The OLEDs using such materials are highly effective, but quite expensive.

In 2012, in order to increase the efficiency of OLED structures, Adachi proposed the use of molecules with a high probability of reverse intercombination conversion (RISC) from the T1 state to the S1 state. In this case, a large proportion of the triplet excitons emit light in the form of thermally activated delayed fluorescence (TADF). To date, a large set of small molecules, dendrimers and polymers with TADF luminescence has been proposed for OLED. The key factor of RISC is the value of the energy gap between the S1 and T1 states. The smaller it is, the more likely the process of reverse intercombination conversion.

In this work, we investigated the photophysical and electroluminescent properties of molecules consisting of electron donor and electron acceptor fragments, in which the RISC process is possible. Electronic spectra of absorption, fluorescence and phosphorescence, the quantum yield of fluorescence in solutions and films obtained by thermal vacuum deposition are investigated. OLED devices have been created, their light and electrical characteristics have been studied.

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STEADY STATE AND TIME RESOLVED FLUORESCENCE STUDY OF EXCITED STATE PROTON TRANSFER IN FLUORESCEIN

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Fluorescein and fluorescein based derivatives are very sensitive indicators of changes in pH, viscosity, pressure, and ionic composition of the local environment. Due to the high absorbance and quantum yield, fluorescein is used for marking and visualizing colorless systems (for example, living cells, proteins, carbon nanotubes) as a fluorescent probe.

It is known that in the ground state, fluorescein in very alkaline conditions at pH > 10–11 exists as dianion in aqueous solution, at pH 5–5.5 – mainly as anion, at pH 3–3.5 the neutral form predominates and in very acidic conditions at pH < 0, the dye is presented as cation. Upon transition to the excited state, the situation changes significantly, especially with the increase in the ion concentration. For example, the neutral form predominates at lower pH 1–2. This is due to the appearance of the proton transfer (nonradiative transition to the other protolytic form with subsequent emission from it) competing with fluorescence. Excited state proton transfer together with the presence of a strong overlap of the emission spectra of individual forms complicates the interpretation of fluorescence so much that there is still no consensus on the number of fluorescent forms and the shape of their contours. This leads to a large scatter in the values of the fluorescence quantum yields and lifetimes of individual protolytic forms. Solving this problem requires the creation of new approaches and research methods.

The work discusses the advantages, limitations and disadvantages of using steady state and time resolved fluorescence methods separately, as well as their combination for study photoinduced proton transfer in the excited state of fluorescein in the presence of a strong spectral overlap of individual protolytic forms.

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B-12

ORGANIC THIN FILM LASERS AND SOME OF THEIR APPLICATIONS

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Recently, there has been an increase in interest in the creation of photoexcited organic thin film lasers, including those based on polymers with semiconducting properties, since intensive work is currently underway to create injection organic lasers and the first results have been obtained. Unlike solid-state lasers based on inorganic materials, organic lasers use a thin layer of organic molecules to amplify light. One of the main advantages of organic lasers is that they can cover the entire visible wavelength range.

When creating thin-film structures, a number of problems arise that must be solved: the search for a highly efficient laser dye with good photostability; the dye must be combined with a solid state matrix; the matrix must have good optical properties; be sufficiently photostable and have good adhesion to the substrate. In addition to the above conditions, for the successful implementation of efficiently emitting thin-film structures, it is necessary to ensure their good waveguide properties.