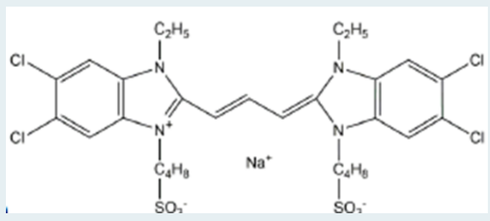
Optical properties of cyanine dye J-aggregate formed in liquid crystal

I.I. Grankina, N.A. Kasian, L.N. Lisetski, S.L. Yefimova, A.V. Sorokin

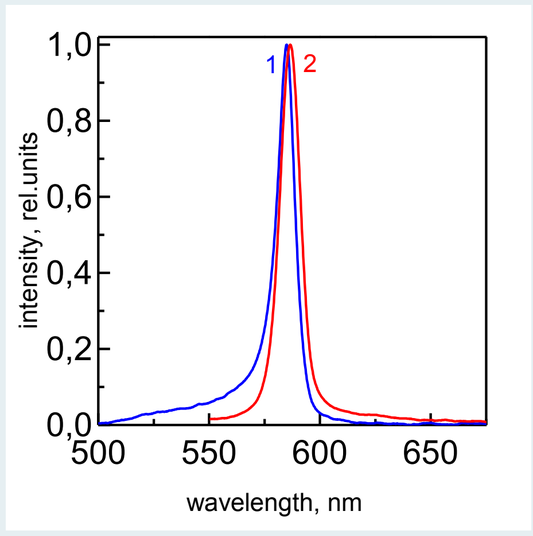
Yu.V. Malyukin Nanostructured Materials Department, Institute for Scintillation Materials of NAS of Ukraine, Kharkiv, Ukraine

Aggregated molecular systems are current subject of interest due to their intriguing optical and electronic properties. Among the various possible associates of chromophores, J-aggregates have attracted a high degree of attention due to their unique photophysical properties. The self-association of dyes in solution or at the solid-liquid interface is a frequently encountered phenomenon in dye chemistry owing to strong intermolecular van der Waals-like attractive forces between the molecules. One of the most **important drawback of** organic dyes is their low photo-stability which reduces the possibility of their commercial utilization. In this work we employ the strategy of dye re-crystallization from oversaturated matrix in order to enhance material's durability. One of the main advantages of cyanine dye is ability to form emissive J-aggregates, good miscibility and incorporation into liquid crystalline matrix. Interesting issue regarding the control of optical properties of photonic materials, i.e. by external electric field, is the utilization of liquid crystals (LCs) as matrices for organic dyes. The number of organic dyes that can be successfully incorporated into liquid crystalline matrix, is limited. Therefore, there is a necessity to design and synthesize new dyes, which can be suitable for LCs matrices. TDBC dyes meet this condition.

(a)

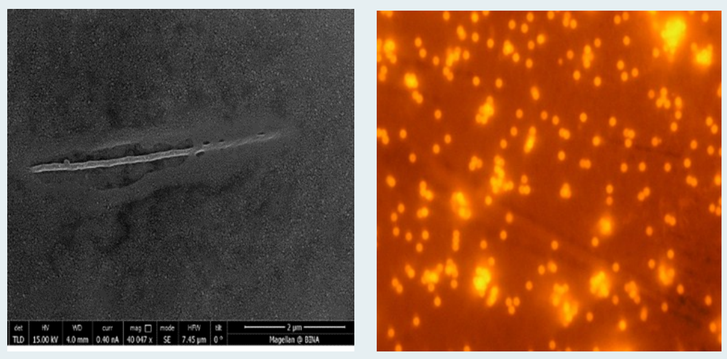


(b)



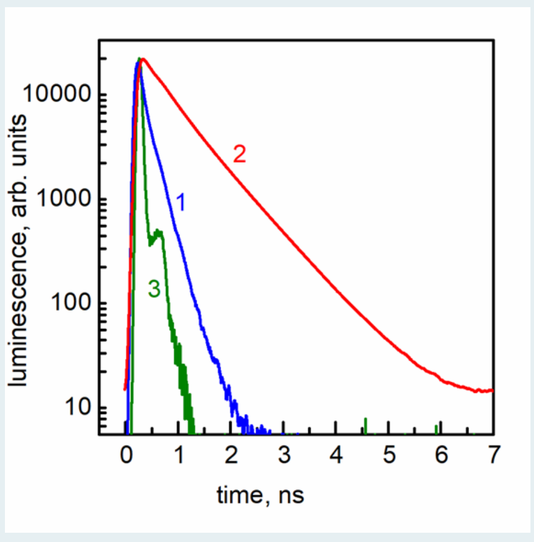
At the dye concentration $C_{TDBC} = 10^{-5}$ M used in our experiments water solution of TDBC dye reveals pronounced J-band and small monomer band seen as a shoulder. The luminescence band ($\lambda_{max} = 587$ nm) reveals very small Stokes shift which is typical for J-aggregates including TDBC J-aggregates. So, one could conclude high ordering within TDBC J-aggregates and small static disorder, which usually disimprove the exciton properties of J-aggregates.

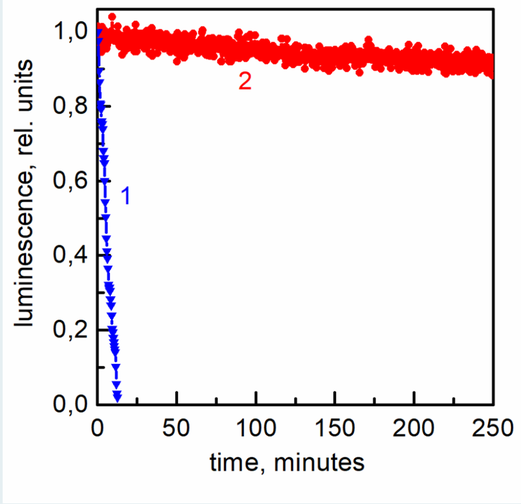
(c)



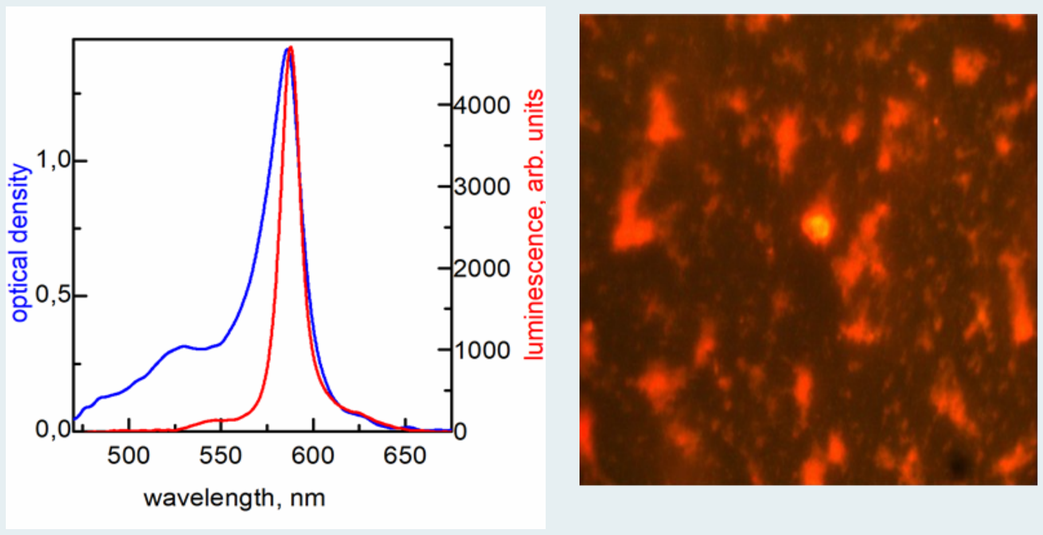
(a) TDBC dye structure, (b) TDBC J-aggregates absorption (1) and luminescence (2) ($\lambda_{exc} = 530$ nm) spectra, (c) SEM images and luminescent image of TDBC J-aggregates

For water solution case the decay curve appears to be not single-exponential and describes by two exponential decays with average lifetime $\tau_{av} \sim 130$ ps (1). In LCs luminescence decays are also fitted by two exponential curves with average lifetime $\tau_{av} \sim 1.21$ ns (2), IRF (3)





(a) **(b)**



(a) Absorption (blue) and luminescence (red, $\lambda_{exc} = 530$ nm) spectra of TDBC J-aggregates formed in LCs. (b) Luminescent image of TDBC J-aggregates formed in LCs.

In water TDBC J-aggregates degrade very fast and their luminescence fully disappear less than for 15 min (1). However, the J-aggregates in LC matrix show only small degradation degree even after 250 minutes of continuous irradiation (2). We can suppose that such very unusual high J-aggregates photostability is associated with individual aggregates spreading over the matrix and their agglomeration preventing.

We have shown that introduced in this work strategy of incorporating dyes like TDBC, exhibiting the strong emission in aggregated form, into LC matrices might be beneficial for the emissive LC materials.

Moreover, presented system proves ultra-high photostability. Such feature is desired for construction of opto-electronic devices.