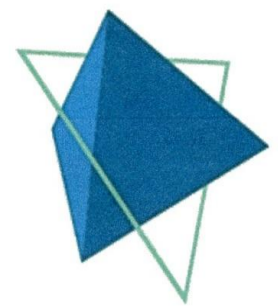


I. V. Klimenko¹, T. Yu. Astakhova¹, E. N. Timokhina¹, A. V. Lobanov A. V.^{1,2}

¹Emanuel Institute of Biochemical Physics of Russian Academy of Sciences, Moscow, Russia,

²Moscow Pedagogical State University, Moscow, Russia

inna@deom.chph.ras.ru

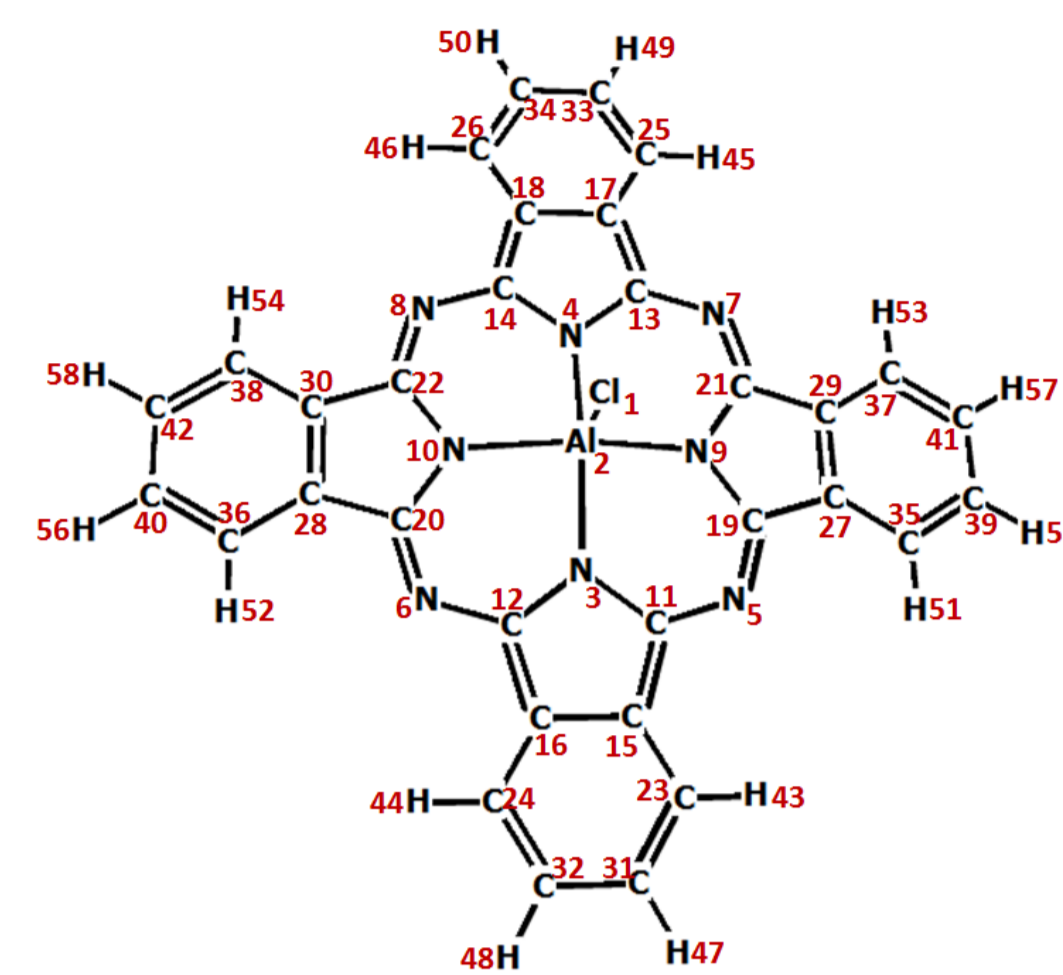


ИБХФ РАН
Институт биохимической физики им. Н.М. Эммуэля
Российской академии наук

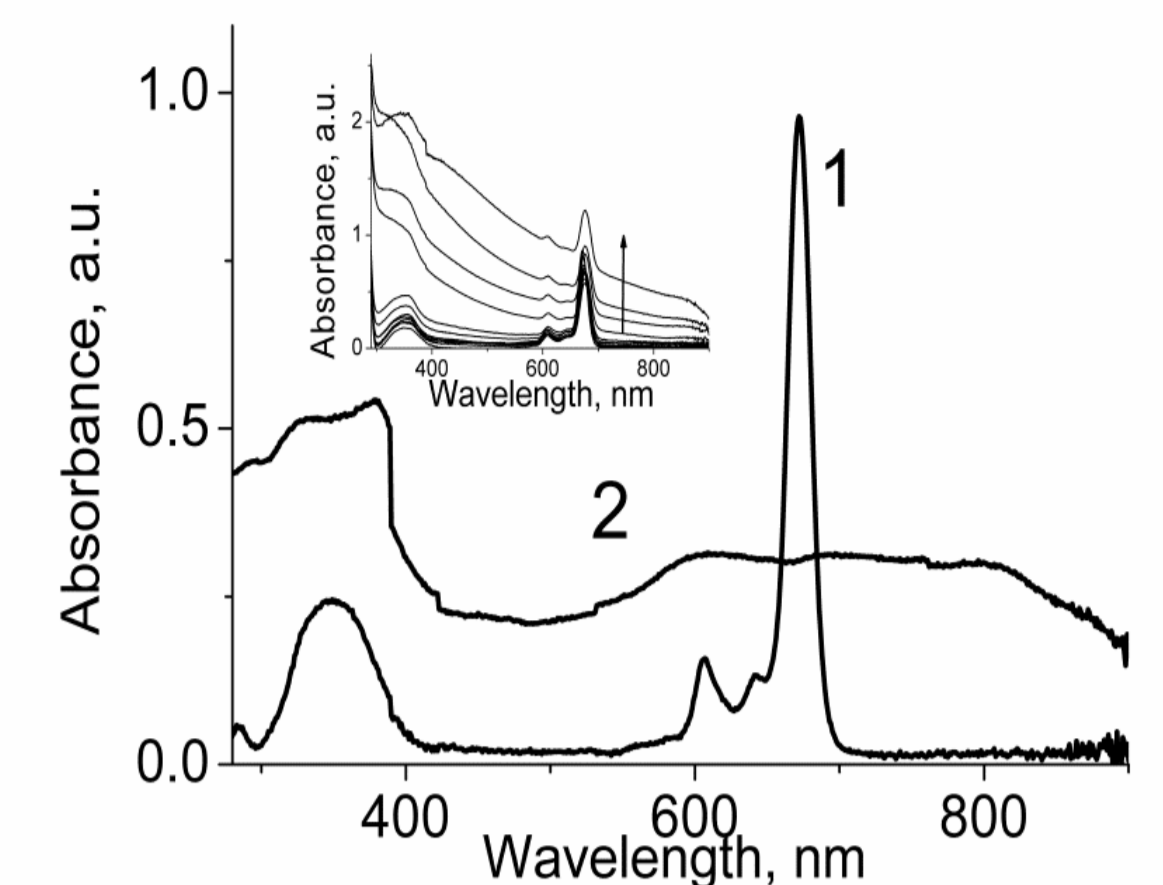
INTRODUCTION

In recent decade, photodynamic therapy (PDT) has become one of the most important treatment for cancer and various neoplasms, as far as in therapy of purulent wounds and trophic ulcers. Tetrapyrrole compounds nowadays are usually used as photosensitizer (Ps), a substance capable of biological tissues photosensitizing. The aromatic macroheterocyclic compound of aluminum phthalocyanine chloride (AlClPc, $C_{32}H_{16}AlClN_8$) is a Ps of a second generation which is characterized by high hydrophobicity, photoactivity and photostability, high absorbance coefficient in the region of 650–680 nm (so-called therapeutic window), high quantum yield of singlet oxygen ($\Phi_{\Delta} = 9.1$) and rather high selective penetration into tumour tissue. But in aqua or aqueous solutions AlClPc has a strong tendency for stacking with the formation of dimers and other types of aggregates, which reduces its photodynamic activity. The understanding of the mechanisms of interchromoform interaction in aqua and aqueous solutions can help in solving the problem of reducing aggregation in aqueous and physiological solutions.

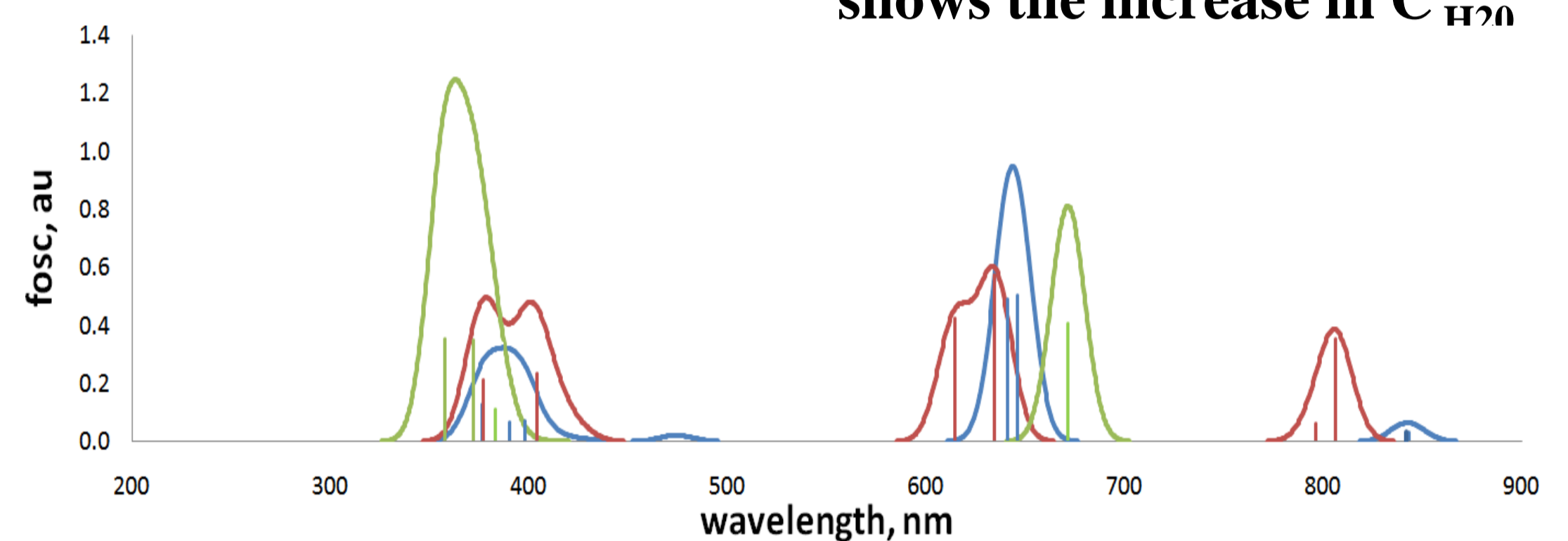
The process of AlClPc complex aggregation in N,N-dimethylformamide (DMF) and DMF-aqua solution with different concentration of aqua was studied by quantum mechanical theoretical calculations and experimental methods of optical absorption and fluorescence spectroscopy.



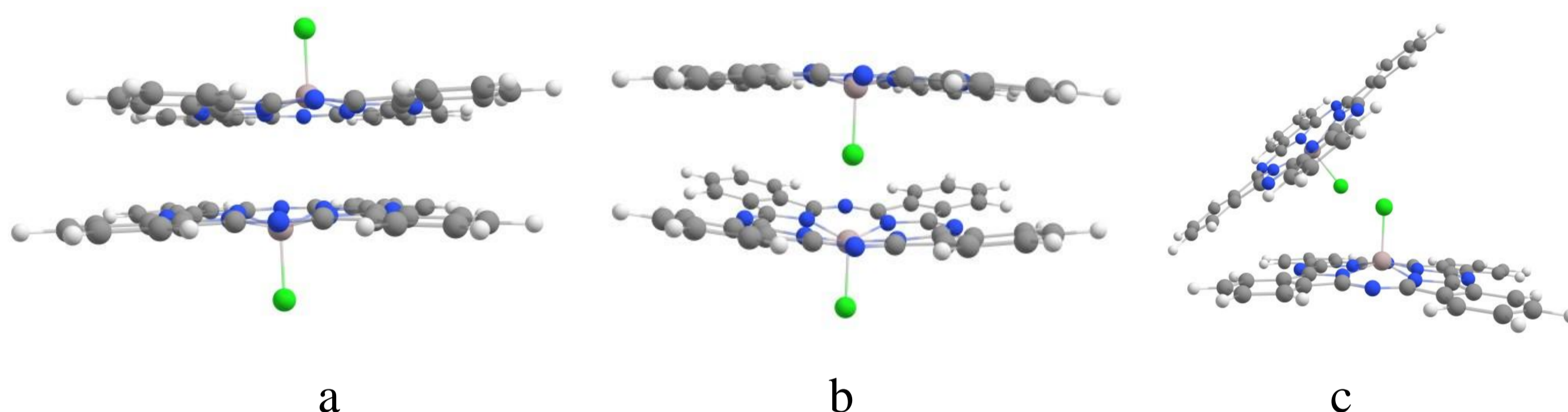
Optimized structure of AlClPc monomer with atomic numbers



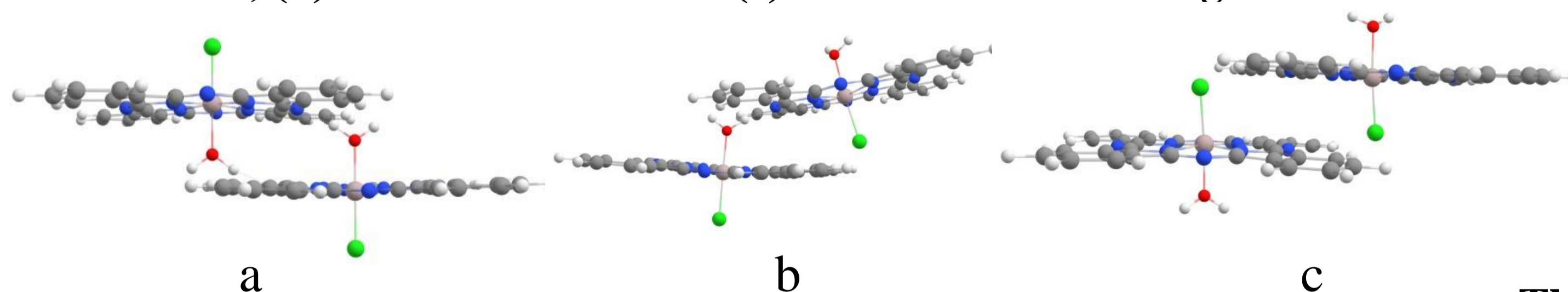
UV-Vis spectra of AlClPc in DMF (1) and DMF-aqua mixture ($C_{H_2O}=15$ vol. %) (2). Inset - UV-Vis spectra of AlClPc in DMF-aqua solution with different concentration of aqua ($C_{H_2O}=1.2 \div 11.1$ vol.%); the arrow shows the increase in C_{H_2O}



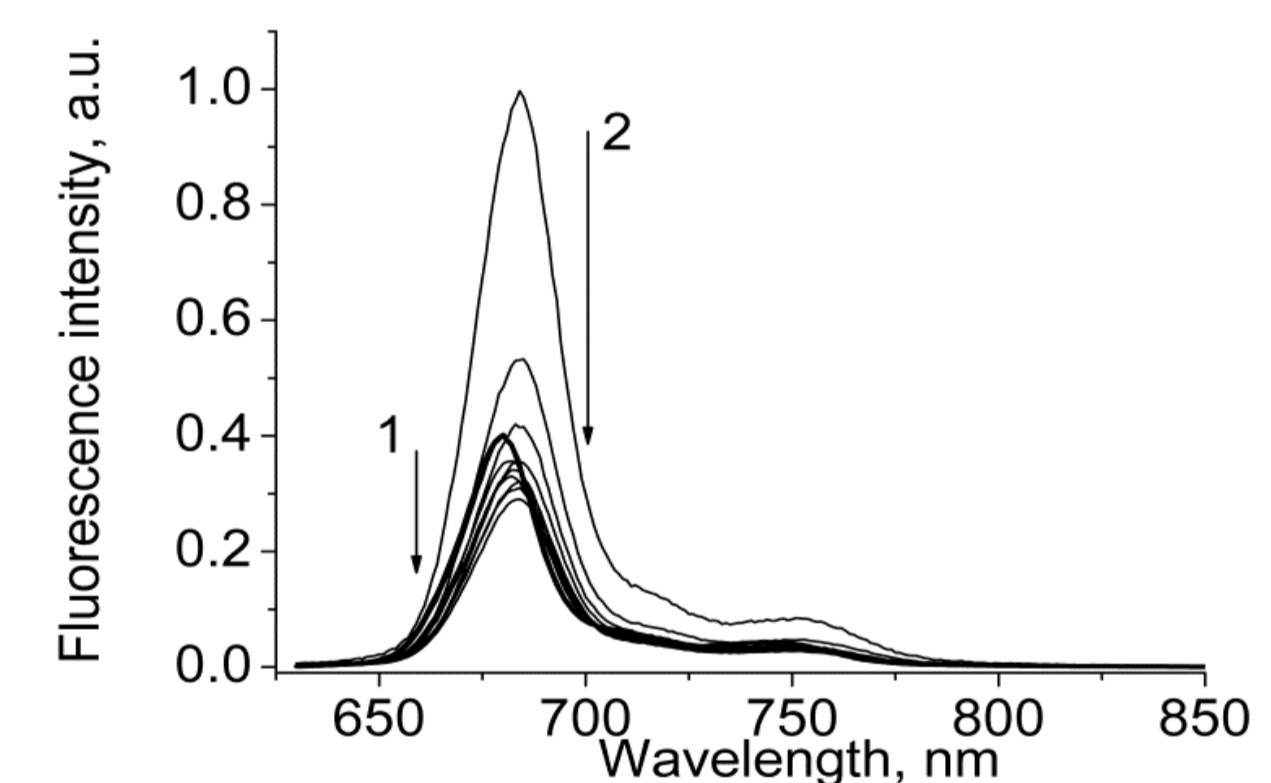
Calculated absorption spectra of AlClPc monomer (1) and dimers in H-aggregate (2) and J-aggregate (3) forms in DMF



Optimized geometries of AlClPc dimers in DMF with: (a) “back-to-back”, (b) “back-to-face” and (c) “face-to-face” arrangements



Optimized geometries of bonded by two H_2O molecules AlClPc dimers with: (a) “back-to-back”, (b) “back-to-face” and (c) “face-to-face” arrangements



The fluorescence spectra of AlClPc in DMF-aqua solution. $C_{H_2O} = 0 \div 12.3$ vol. %. $\lambda_{ex} = 610$ nm. The arrows show the increase in aqua concentration: 1 - from 0 to 6.7 vol. %, 2 - from 7.8 to 12.3 vol. %

RESULTS AND CONCLUSIONS

- All experimental and theoretical studies show the dependence the photophysical parameters of AlClPc on its aggregation properties and the monomer-dimer ratio in solutions, that are determined by the dye concentration in the medium.
- In aqua-organic media the metal cation in the AlClPc molecule becomes six-coordinated, with two extraligands directed on opposite sides of the AlClPc macrocycle plane. Reduced solubilization capacity of the aqua-organic medium stimulates aggregation of AlClPc.
- The higher the concentration of Pc in the solution and the greater the proportion of aqua in the aqua -DMF binary system, the higher the degree of AlClPc aggregation.
- A critical concentration of aqua in system (~ 7.8 vol. %) when the ratio of monomers and dimers (J-aggregates) of AlClPc changes dramatically has been determined.
- In pure DMF AlClPc is completely in monomeric form.
- This solvatochromic effect also makes it possible to predict the aggregation behavior of AlClPc complexes in various media in hybrid materials, as well as to control and manage their aggregation behavior.