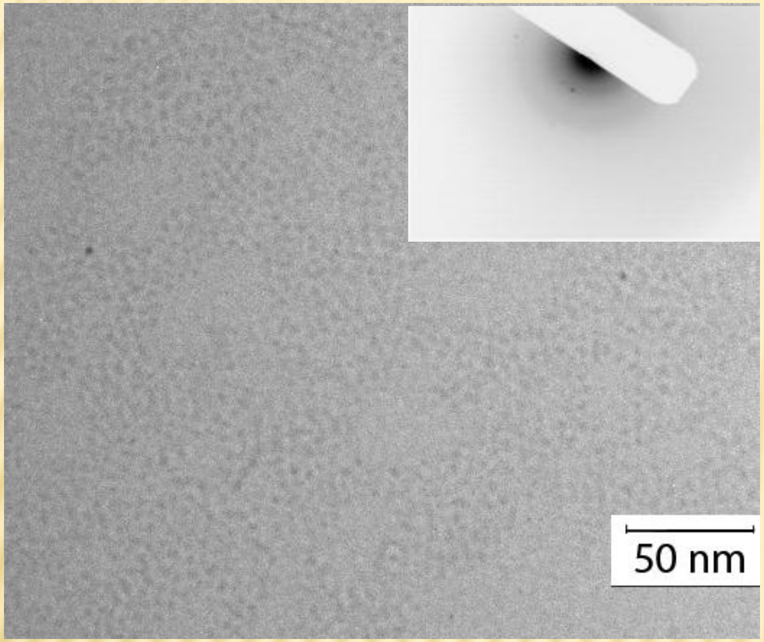
Zhmurin P.
ISMA NAS, Kharkov, Ukraine

NANO PARTICLE UPLOADED PLASTIC

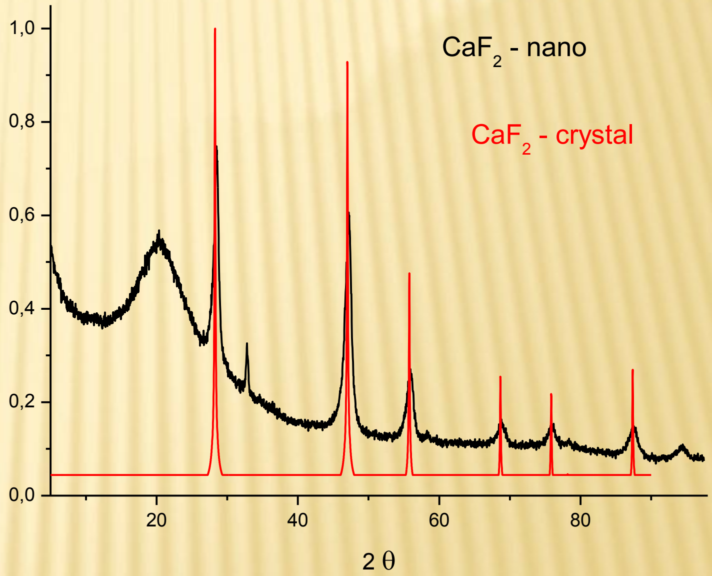
- Nanoparticles as the main component of the scintillator
- Nanoparticles as the activator for plastic scintillator
- Nanoparticles as the convertor for plastic scintillator

- The main method of nanocrystals obtaining – precipitation reaction
- Nanocrystals $CaF_2:Eu^{2+}$ - the most suitable base for the creation of efficient scintillator
- Nanocrystals $CaF_2:Eu^{2+}$ - are easily produced by the precipitation reaction
- Bulk crystal $CaF_2:Eu^{2+}$ have the highest level of the light yield (among the crystals available for the nanocrystal producing)

NANOCRYSTALS $CaF_2:E^{2+}$

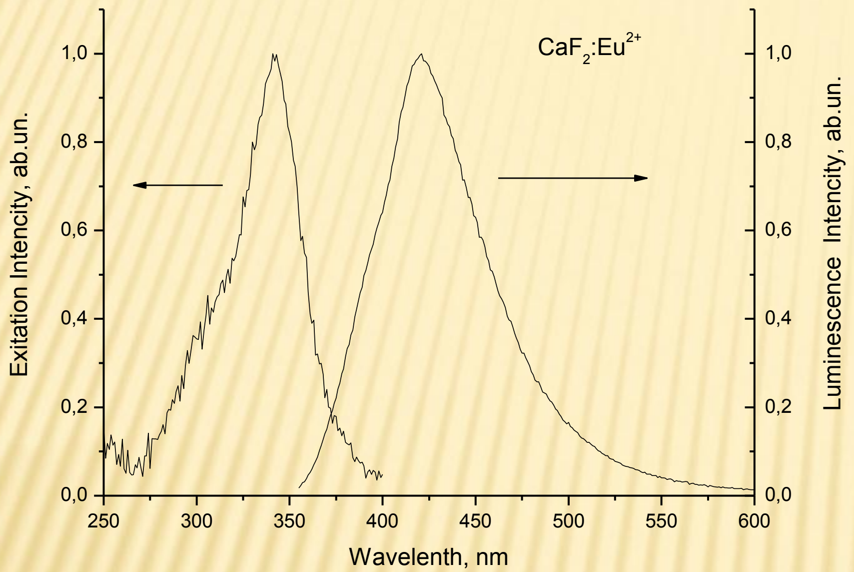


Average nanocrystal size – 12 nm

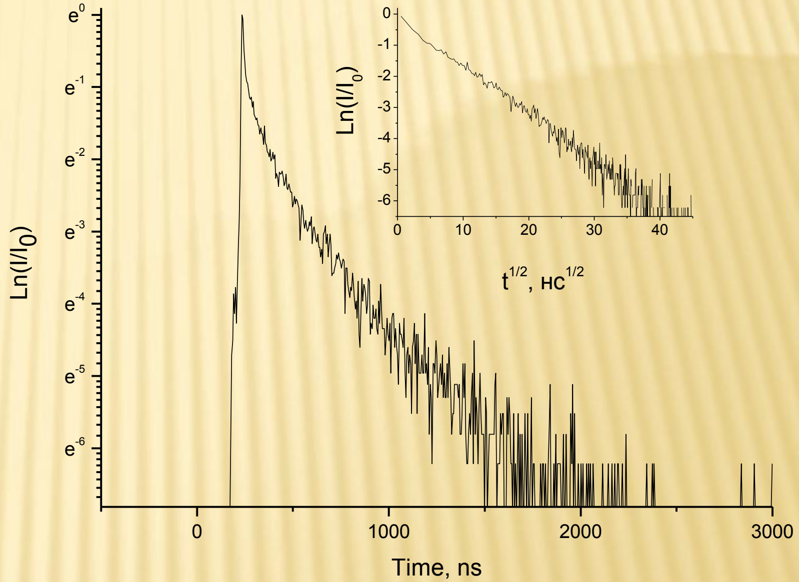


X-ray diffraction patterns of the bulk- and nano-crysnals

SPECTROSCOPIC PROPERTY



Excitation and luminescence spectra



Decay time

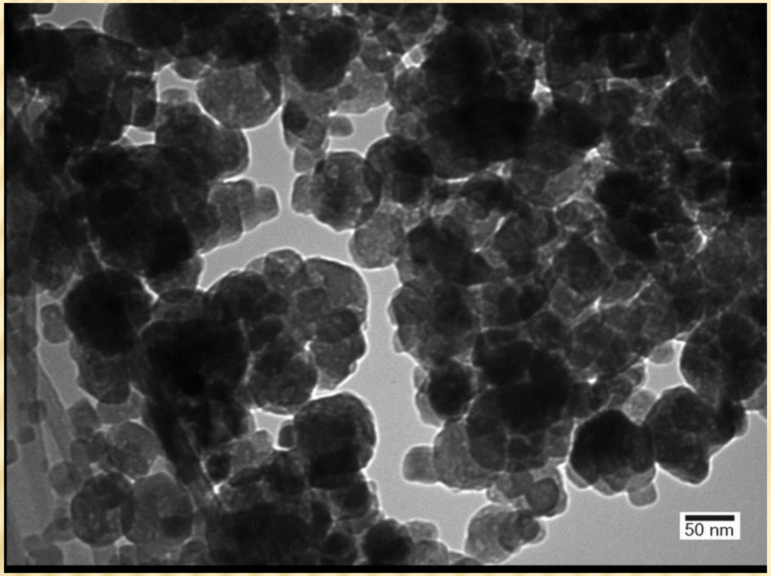
$$I/I_0 = \exp(-t/\tau_0 - qc_a R_0^3 \sqrt{t/\tau_0})$$

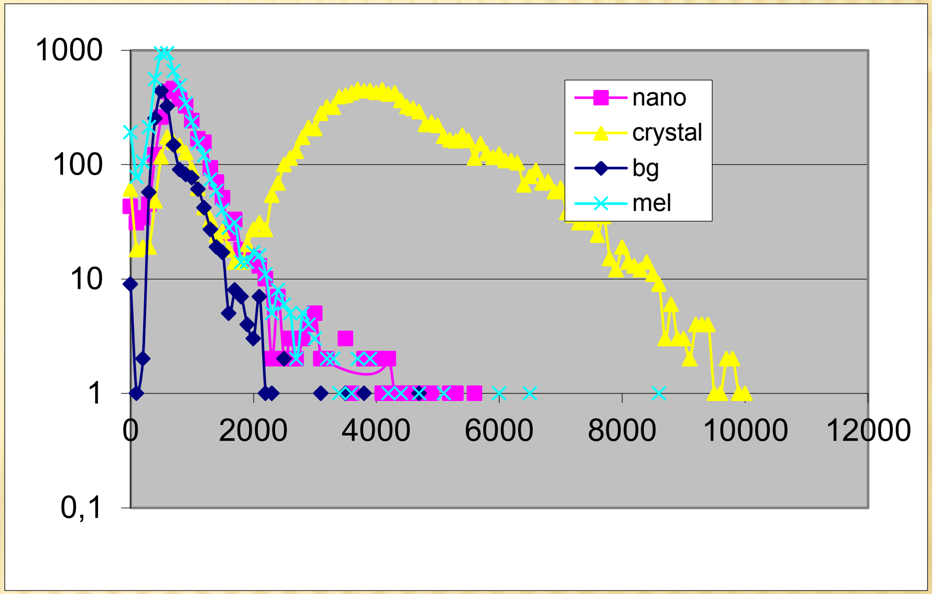
$$\gamma = \frac{qc_a R_0^3}{2}$$

$$I/I_0 = \exp(-t/\tau_0 - qc_a R_0^3 \sqrt{t/\tau_0})$$

Quantum yield – 16% in comparison with bulk crystals

SPECTROSCOPIC PROPERTY

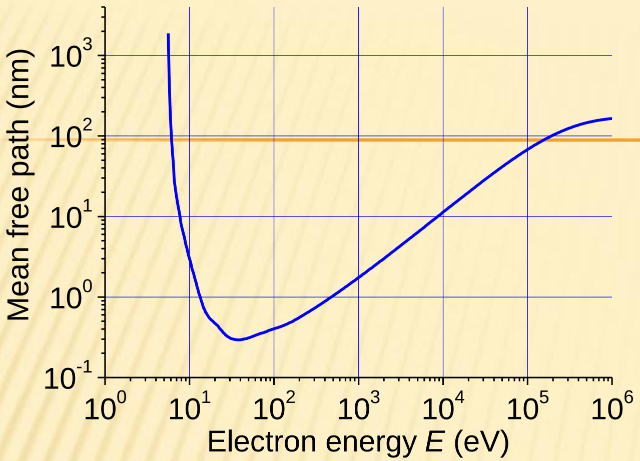


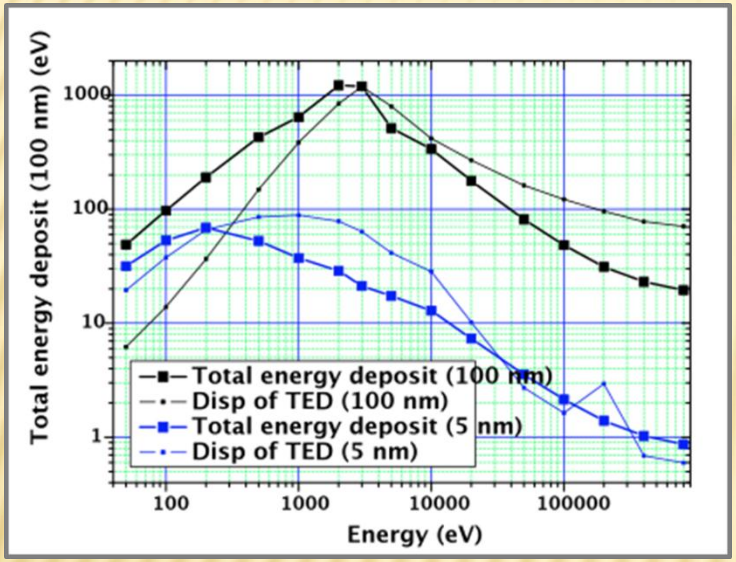


Annealed (1000K) nanocrystals .
Average nanocrystals size – 50 nm

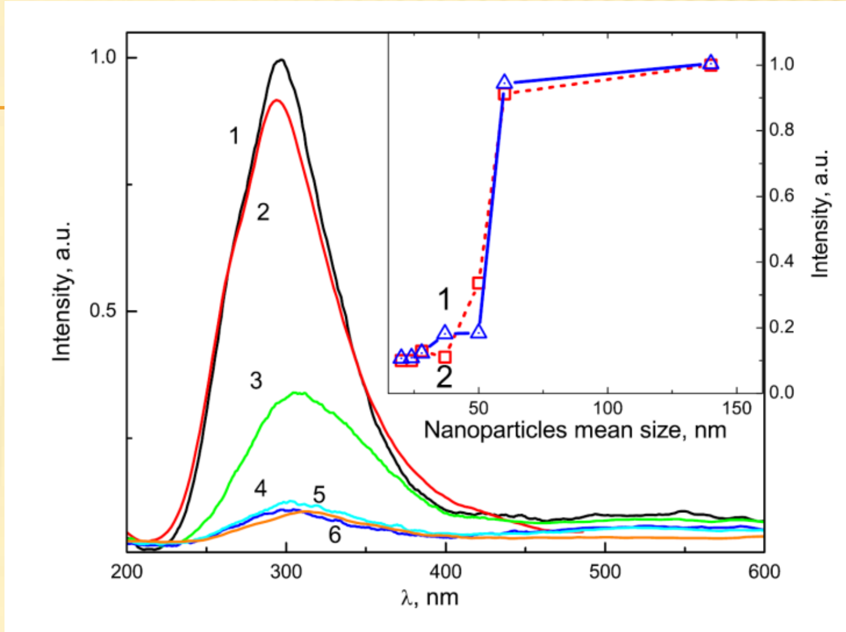
Scintillation efficiency of nanocrystals and annealed nanocrystals

Nanocrystals do not have any scintillation efficiency





A.N.Vasil’ev, A.Belsky, A.L.Bulin and C.Dujardin



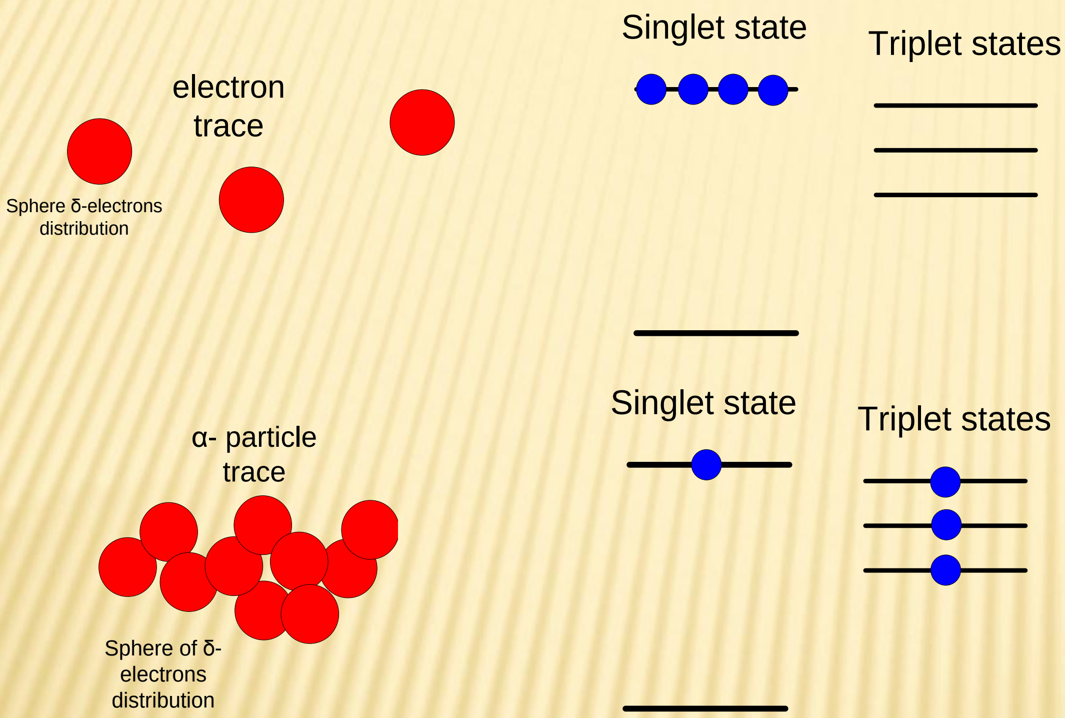
V. V. Vistovskyy,[1] A. V. Zhyshkovych,[1] N. E. Mitina,[2] A. S. Zaichenko,[2] A. V. Gektin,[3] A. N. Vasil’ev,[4] and A. S. Voloshinovskii[1]

Luminescence yield for different size of nano particles irradiated by x-rays

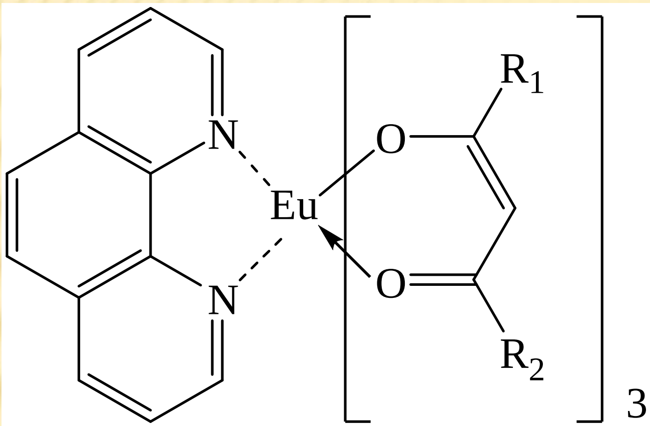
Similar results are obtained by another authors

- So, it is obvious that the way of new scintillator creation based on nanocrystals is not efficient.
- But there is more interesting way for nanoparticles using - modification of plastic scintillator property

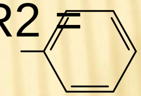
TRIPLET STATES EXCITATION REGISTRATION

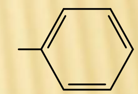


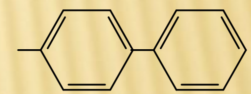
- Plastic scintillator efficiency is directly connected with the distribution of excited states between singlet and triplets states of the polymer molecules.
- The higher plasma density in the trace, the lower the level of a singlet state population of chromophore parts of the polymeric molecule.
- If two centers are created in a plastic scintillator, and each of them can collect energy from triplet and singlet states only, then the plastic scintillator will be sensitive to the particles type .

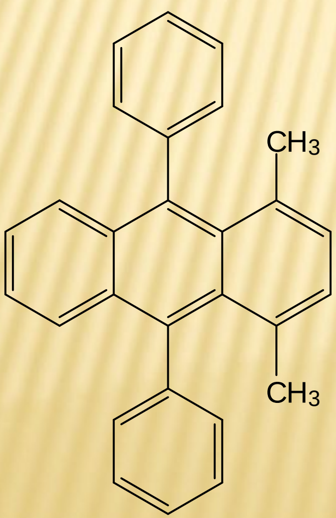


AA R1 = R2 = CH_3

DBzM R1 = R2 = 

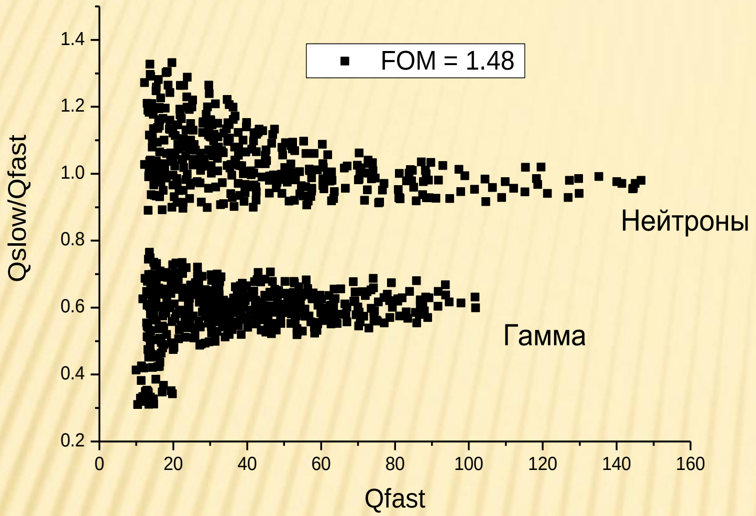
BzA R1 = CH3; R2 = 

BPA R1 = CH3 ; R2 = 



The use of metal organic complexes permits triplet excite energy registration due to the strong spin orbit interaction

Singlet levels can be excited in a dye organic molecule



As the result plastic scintillator will be available to detect neutrons in a γ background presence .

There is question.

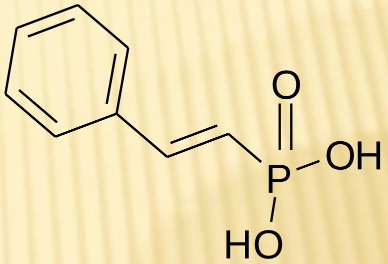
How nanocrystals can collect energy from excited triplet energy states.

Номер образца ПС	Содержание добавок в ПС*, мас.%			n/γ-разделение, FOM	Максимум люминесц. ПС, нм
	Триплетный активатор	Синглетный активатор	Сместитель спектра		
1	2,5% Eu[DBM]3Phen	0,7% DMDPA	0,03% L59	1,35	598 и 612
2	3,0% Eu[DBM]3Phen	1,0% DMDPA	0,05% L59	1,48	598 и 612
3	3,5% Eu[DBM]3Phen	1,5% DMDPA	0,04% L59	1,36	598 и 612
4	2,0% Eu[DBM]3Phen	1,0% DMDPA	0,03% L59	1,03	598 и 612
5	4,0% Eu[DBM]3Phen	1,0% DMDPA	0,03% L59	1,2	598 и 612
6	3,0% Eu[DBM]3Phen	2,0% DMDPA	0,03% L59	1,23	598 и 612
7	3,0% Eu[DBM]3Phen	0,5% DMDPA	0,03% L59	1,21	598 и 612

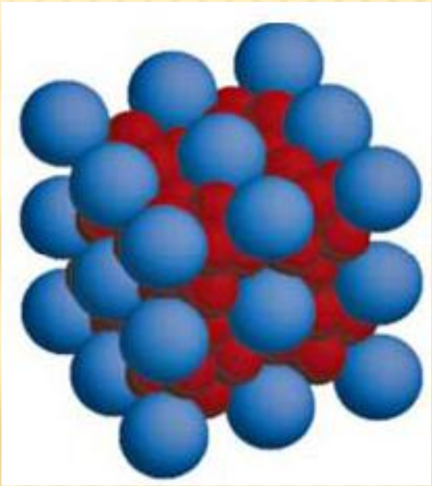
- And a third way of nanoparticles using - filling the polymer base of plastic scintillator (polystyrene) by the neutron sensitive elements (Li, B, Cd, Gd), that are the part of a nanocrystal material (LiF, CdF_3..)
- Main problem - searching such an organic coating for a nanoparticle that provide maximum dispersion level in the polystyrene media

ORGANIC COAT OF THE NANOPARTICLE

Digeksadetsilditiofosfat ammonium
$(C_{16}H_{33}O)_2PS_2NH_4$



2- feniletilenfosfonovaya acid



Nanoparticle in organic coat

DISPERSION NANOPARTICLES IN LIQUID MEDIA

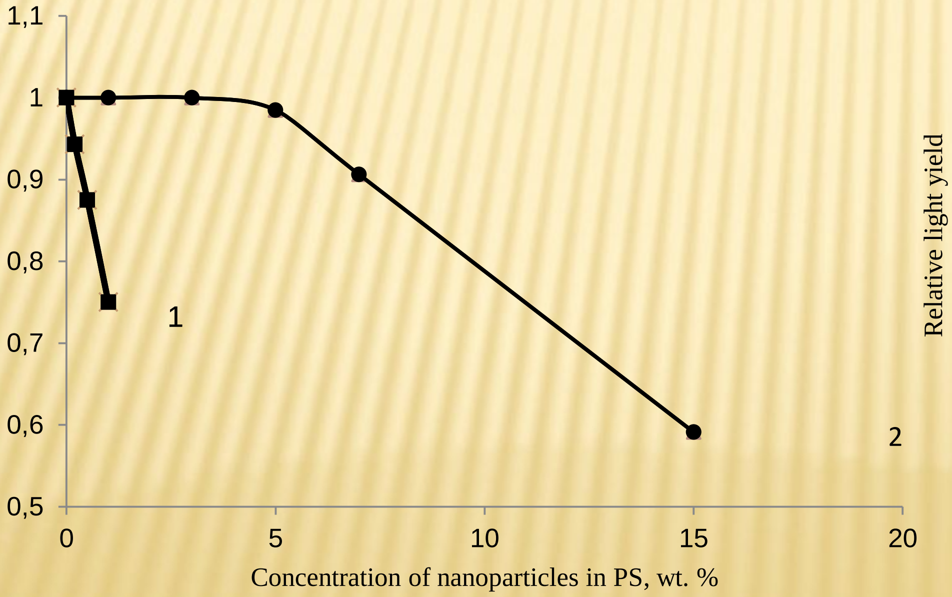
Solutions of gadolinium fluoride nanoparticles
1 - GdF_3 by дицетилдитиофосфатом;
2 - GdF_3 with a surface coated by олеиновой кислотой;
3 – methylen chlorine without additives

Synthesized nanoparticles can «enrich» bases of liquid scintillators up to 20% level without significant change of their transparency

Nanoparticles dispersion in polystyrene

a	b	c	d	f

Polystyrene scintillator, that contain 1 (a), 3 (b), 5 (c), 7 (d), 15 (f) wait % nanoparticles GdF_3, stabilized by Digeksadetsilditiofosfat ammonium and 2- feniletilenfosfonovaya acid



Scintillation efficiency versus of the Concentration nanoparticles in PS

CONCLUSION

- The loading polymeric base of plastic scintillator by the nanoparticles is effective method for the modification it property for different application.
- It is necessary to know detail energy transfer between nanoparticles and excited states polymeric environment for the creations new properties of plastic scintillator.

Thank you for attention