National Academy of Sciences of Ukraine
Institute of Physics

Charge separated state of phenothiazine upon adsorption on crystal of laponite

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NANOTECHNOLOGY: from fundamental research to innovations
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Work team

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Introduction

Charge separation state (CSS) of dye molecule is temporary loss of electron(s) due to interaction with electromagnetic radiation (*fast electrons, γ-ray, X-ray, far-UV light or visible light*).

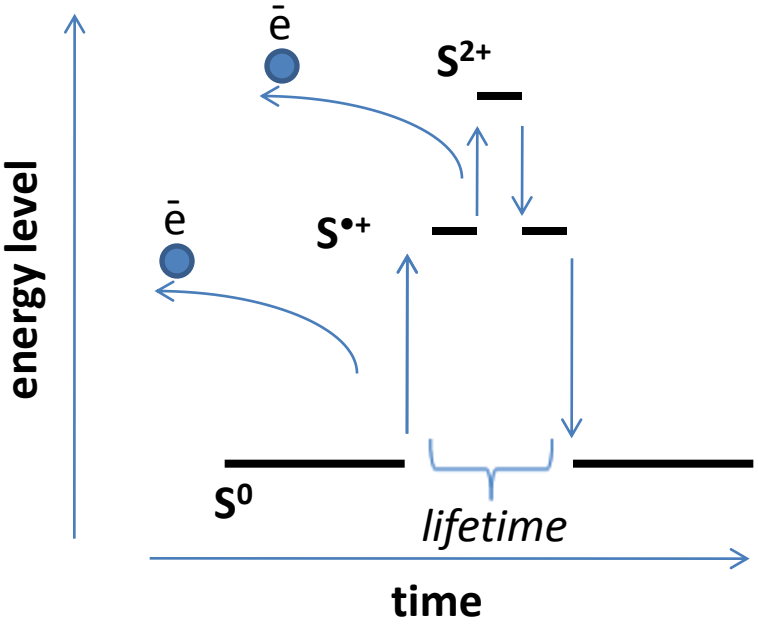
The ***lifetimes of the CSS*** in solid state are about 10^{-15} seconds and in solution are less than 10^{-6} seconds. So fast processes produce some technical difficulties in research. Therefore, for study of CSS the molecules are placed in the pores of materials where the lifetime increases up to 10^5-10^6 seconds (~from few days up to year).

Such materials can be very interesting for **fundamental studies of CSS**.

The main direction of fundamental study of this composite have a goal to increase the lifetime of the dye's radicals.

Another direction of research is study the effect of radiation on dye's radicals.

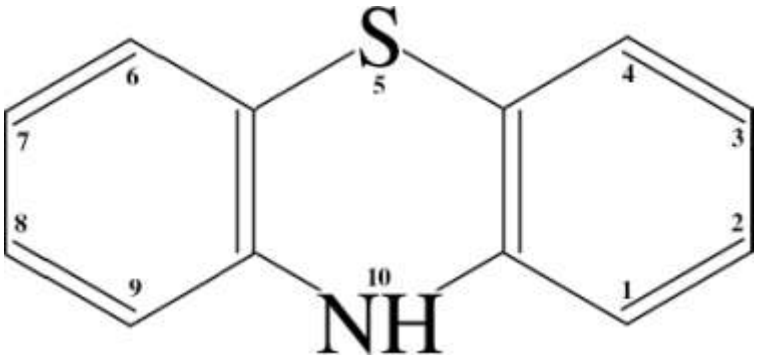
Our main goal of the research is to create composites with as small lifetime as possible.

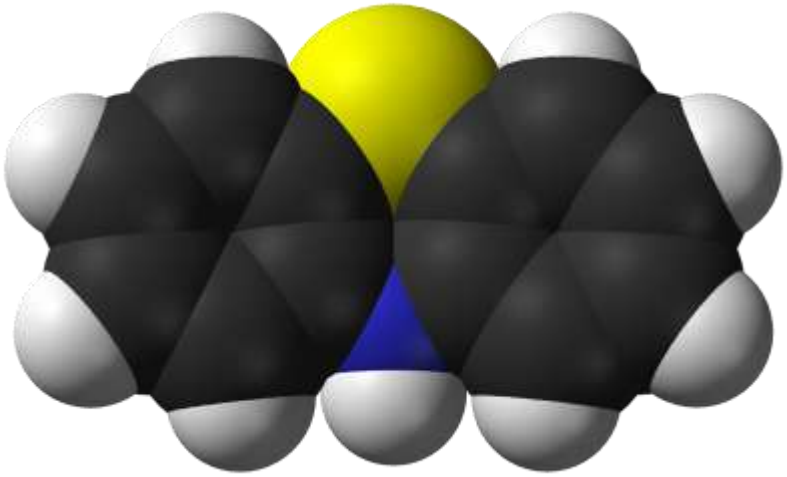


Reactions

Reaction Equation	Event Description
$E_{h\nu} + S \rightarrow S^*$	Dye excitation
$S^* \rightarrow E_{h\nu} + S$	Dye relaxation
$S^+ + A^- \rightarrow S + A$	Dye regeneration
$S^* + TiO_2 \rightarrow e^*_{TiO_2} + S^+$	Electron injection
$S^+ + e^*_{TiO_2} \rightarrow TiO_2 + S^*$	Dye recombination
$e^*_{TiO_2} + A \rightarrow A^-$	Electrolyte recombination
$e^*_{TiO_2} + FTO \rightarrow e_I$	Current collection
$e_I + A \rightarrow A^-$	Electrolyte reduction

Phenothiazine (PTZ)





Thermal properties	
Melting point	182—187 °C
Boiling point	371 °C
Temperature of destruction	371 °C
Chemical properties	
Solubility in water	0,00051 g/100 ml
Solubility in acetone	20 g/100 ml

Laponite RD*

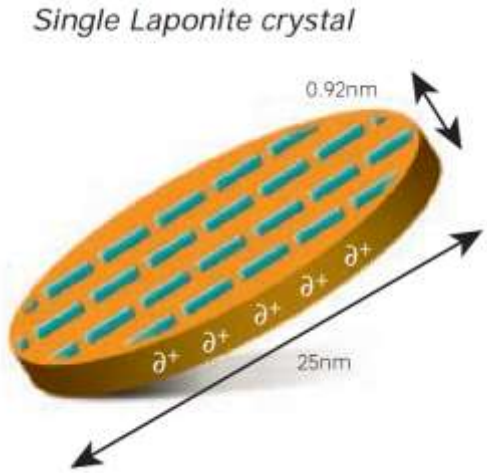
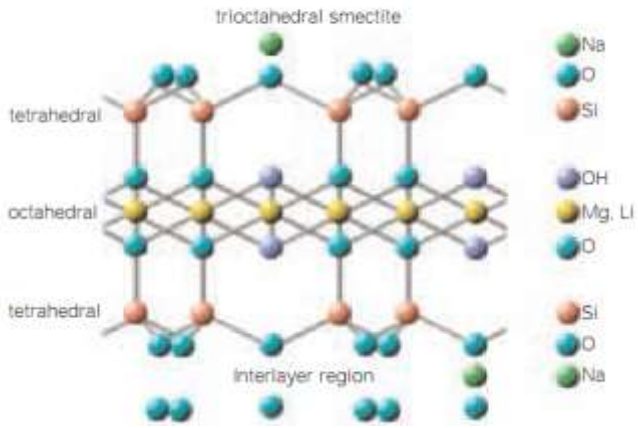


Figure 2. Idealised structural formula



Property	
Appearance	free flowing white powder
Bulk Density	1000 kg/m3
pH (2% suspension)	9.8
Sieve Analysis	2% Max >250 microns
Surface Area (BET)	370 m^2/g

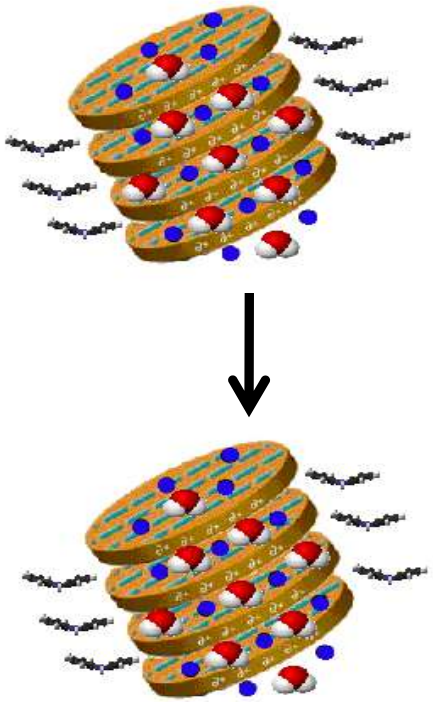
Chemical Composition (dry basis)	
SiO_2	59.5%
MgO	27.5%
Li_2O	0.8%
Na_2O	2.8%
Loss on Ignition	8.2%

*http://www.scprod.com/product_bulletins/PB%20Laponite%20RD.pdf

Methods of preparation

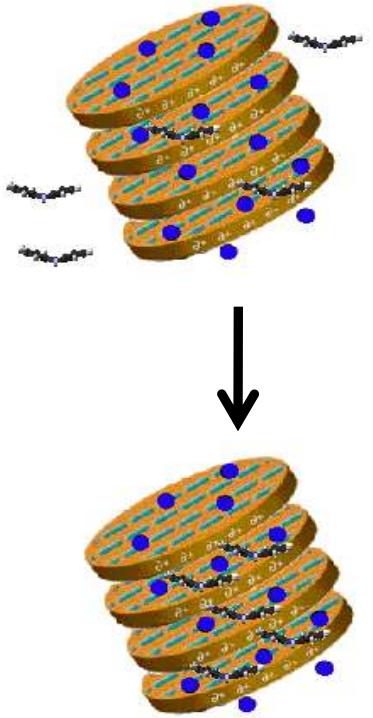
Method 1

1. + PTZ



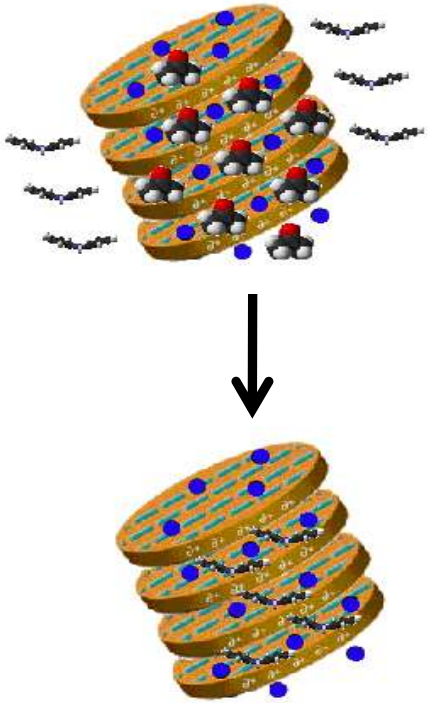
Method 2

1. Heat (200°C)
2. + PTZ



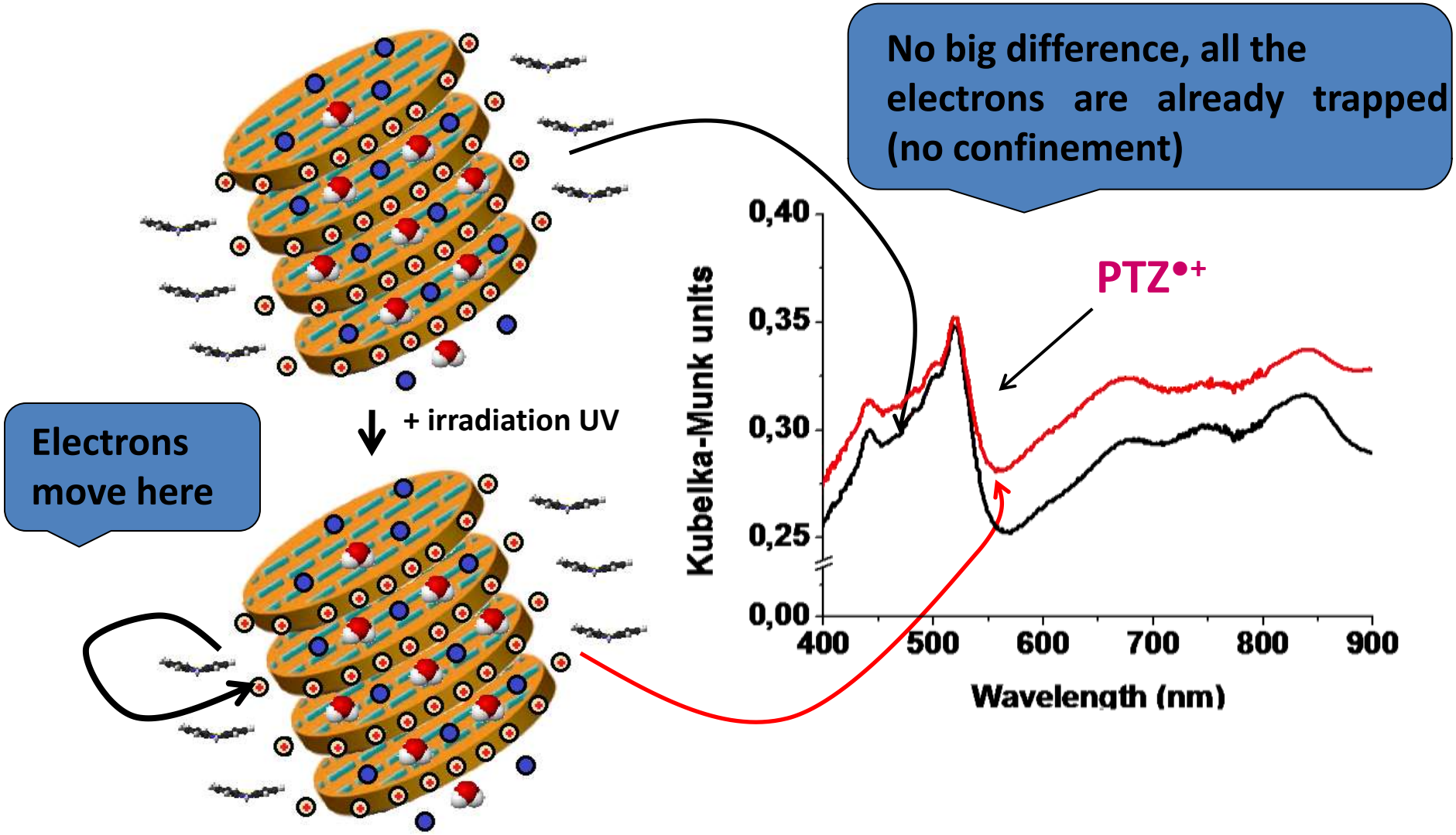
Method 3

1. + acetone
2. + PTZ

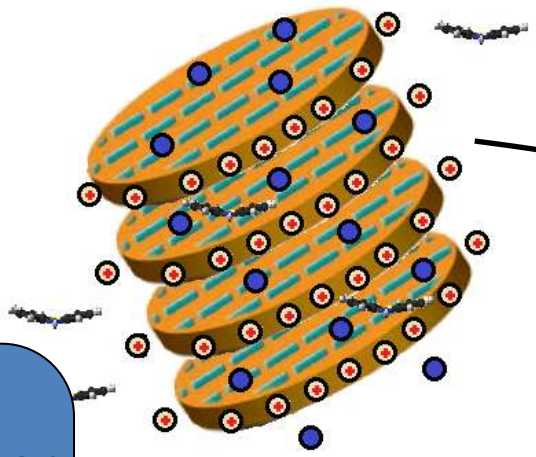


- PTZ - H_2O - acetone - Na^+

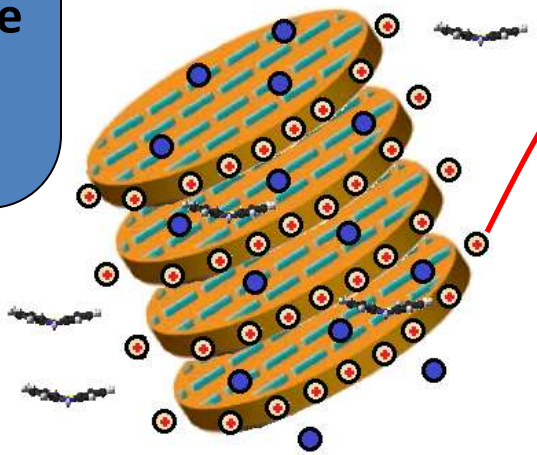
Diffuse reflection visible absorption spectroscopy (method 1)



Diffuse reflection visible absorption spectroscopy (method 2)

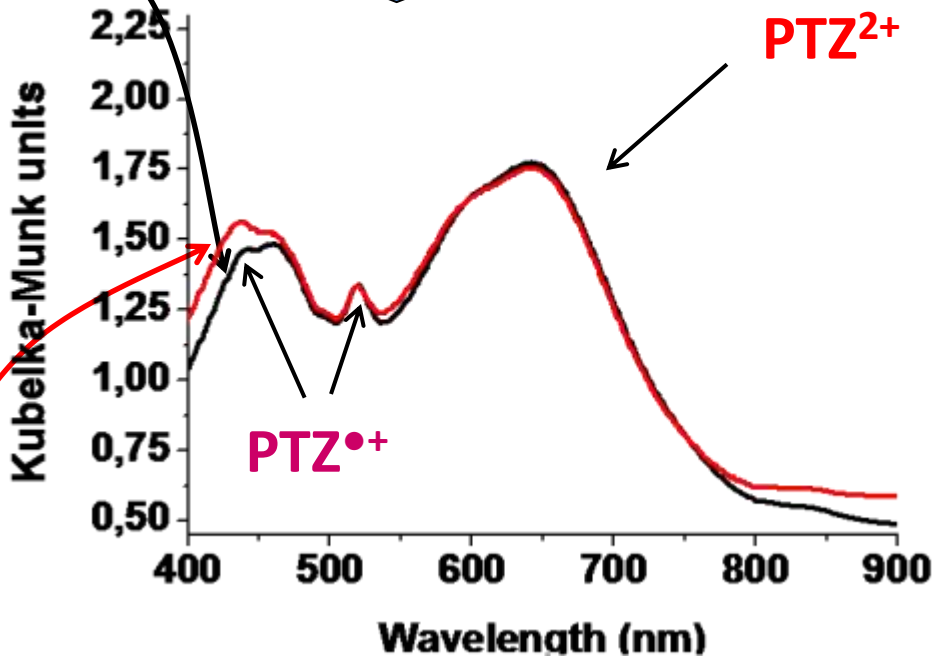


+ irradiation UV

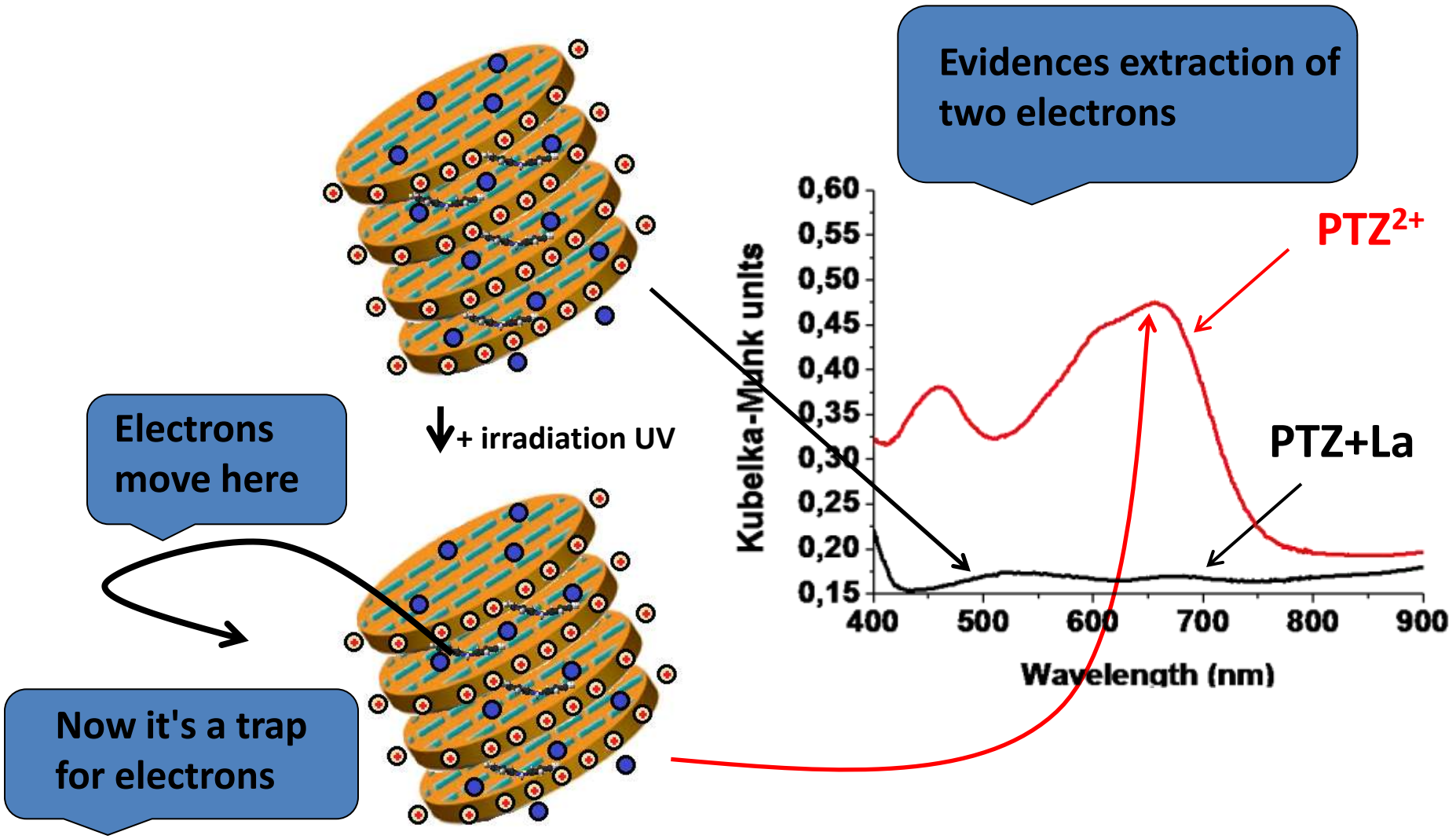


Molecules are adsorbed both on the outer surface and between the Laponite sheets

No big difference, all the electrons are already trapped



Diffuse reflection visible absorption spectroscopy (method 3)



Conclusions

1. **Prepared and studied composites based on Laponite platelets and dye PTZ exhibit the long lived CSS with small lifetime of 2 electrons state, which is absent in the pure PTZ under the same conditions.**
2. **The methods of preparation affect spontaneous ionization of the dye molecules and allow obtaining of composites with different ionization properties.**
3. **Extraction of 2 electrons from one PTZ molecule is observed for composites prepared using method 3. Relaxation of dye molecules to their original state occurs in the absence of light. This effect can be promising for future application in solar panels.**