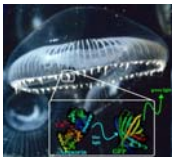
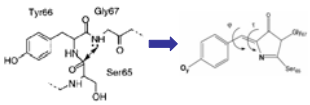
Modeling properties of the chromophore from the green fluorescent protein

Bella Grigorenko, Igor Polyakov, Alexander Nemukhin
Department of Chemistry, M.V. Lomonosov Moscow State University, Moscow, Russia

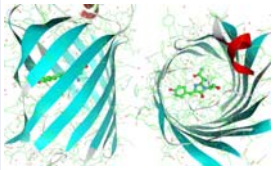
What did we learn from the literature?

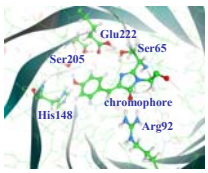


Chromophore formation

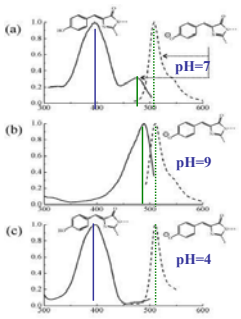


Active site of GFP

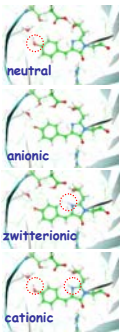




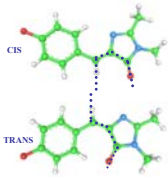
Spectra of GFP



The chromophore can exists in four protonation forms

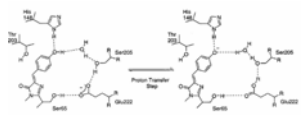


In some GFP-like proteins (KFP, mKate, rtms, Dronpa) the trans-cis isomeri-zation takes place



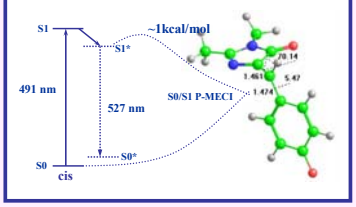
Current hypothesis

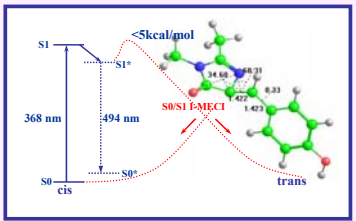
The neutral form is responsible for absorption at 395 nm
The anionic form is responsible for emission at 508 nm



Motivation

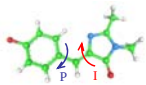
We intend to verify by computational experiments the current hypothesis on the fluorescence process in GFP and suggest our own viewpoint



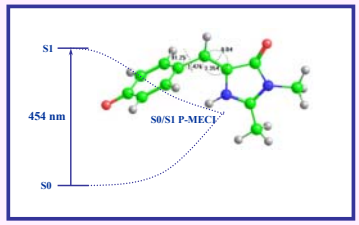


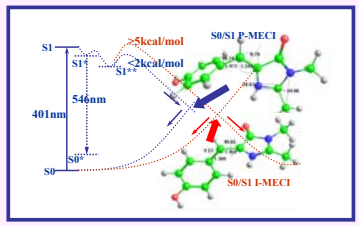
Minimum energy conical intersections (MECI) have been located by using the CASSCF(12,11)/cc-PVDZ approach

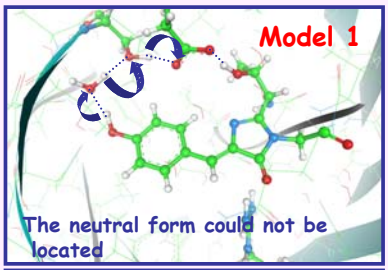
The shape of the excited state potential energy surface along the torsion angles is essential

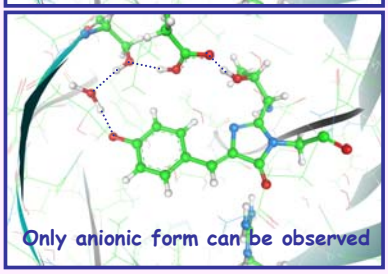


In the gas phase the GFP chromophore does not emit due to the conical intersections for all protonation forms. This is consistent with experimental observations.





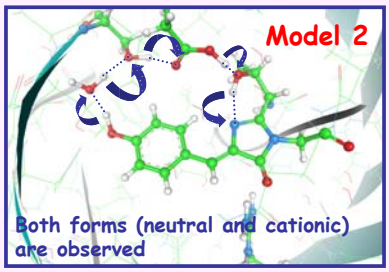


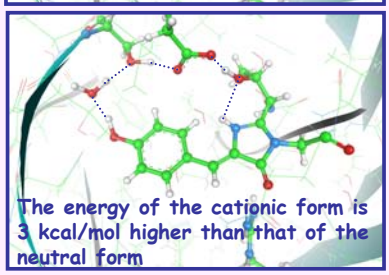


Geometry parameters have been optimized by using the QM/MM technique
QM:PBE0/6-31G(d); MM:Amber

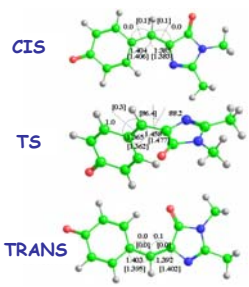
In the protein we consider two possible models for the GFP chromophore:
Model 1: the neutral/anionic pair
Model 2: the neutral/cationic pair

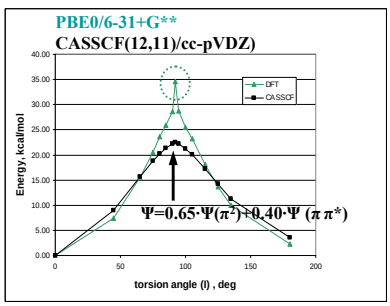
CONCLUSION:
the NEUTRAL form absorbs and the CATIONIC form emits

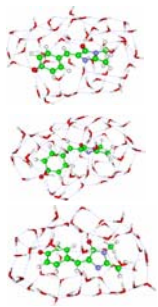




Modeling cis-trans isomerization of the anionic form of the GFP chromophore in the gas phase and aqueous solution







	dielectric continuum model	DFT	CASSCF	Experiment (He,2003)
cis	0	0	0	0
TS	9,9	26	11,1	13,1
trans	2,6	5	2,1	2,3

The CASSCF energy profile is consistent with the experimental data