Metal-Enhanced Fluorescence of Dye Molecules using Ag Nano Particles

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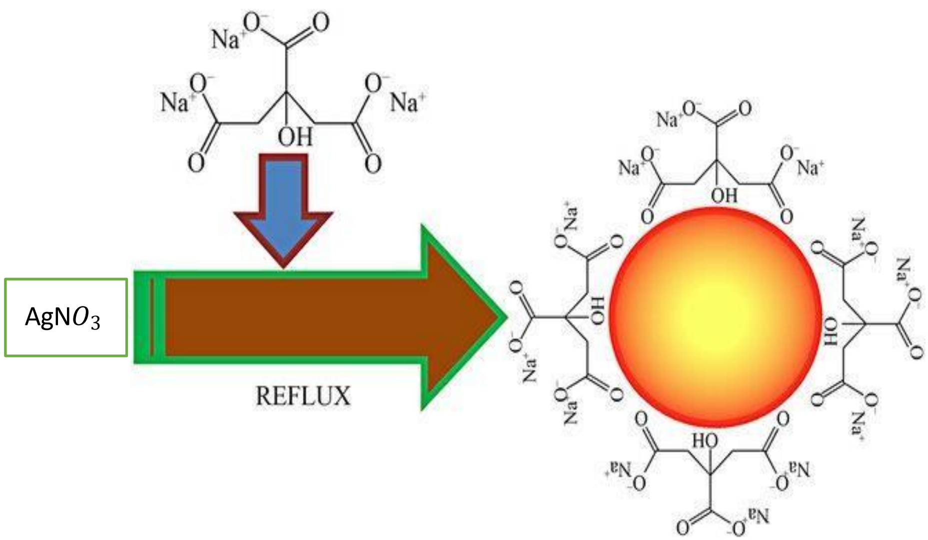
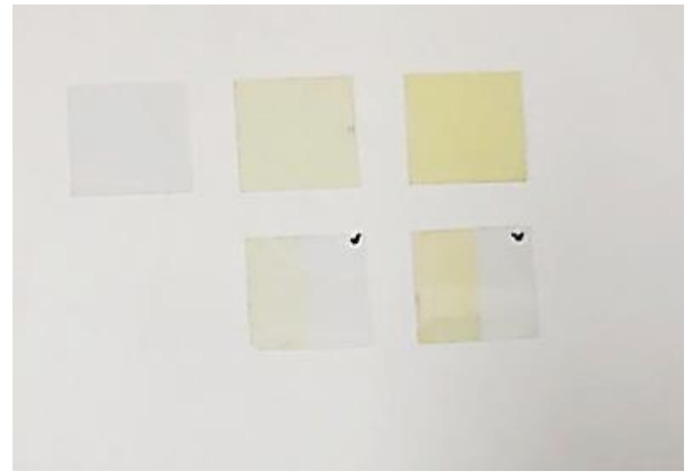
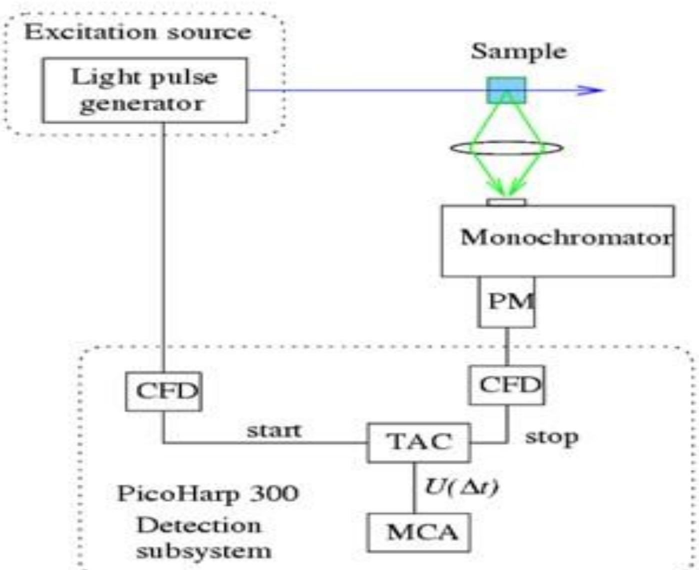
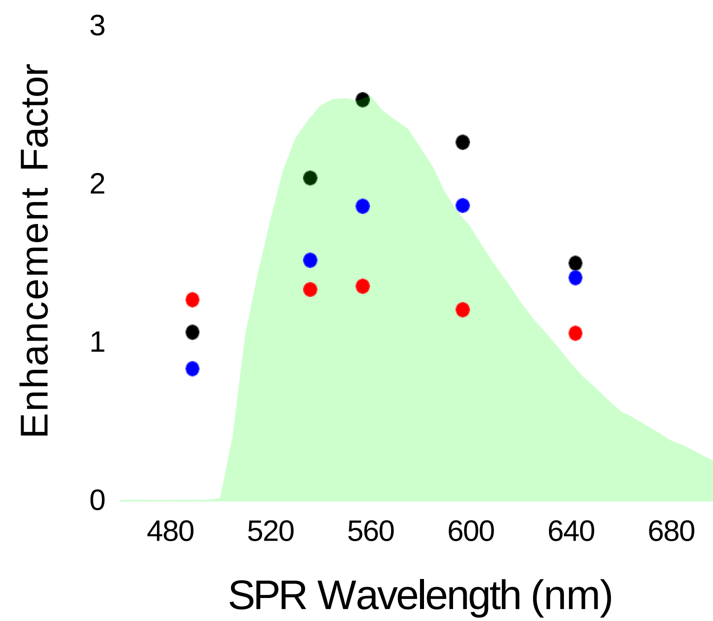
2019.08.09

01 INTRODUCTION



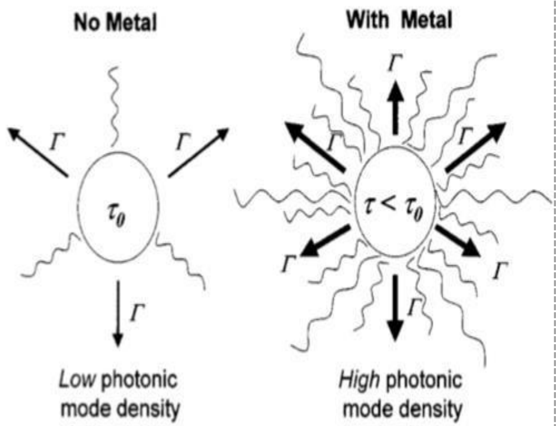




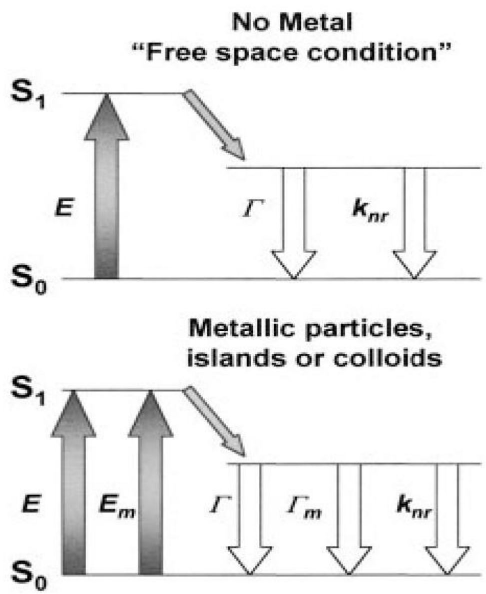


01 INTRODUCTION

Metal Enhanced Fluorescence ▼



Low and high photonic mode densities in the absence and presence of metal, respectively.



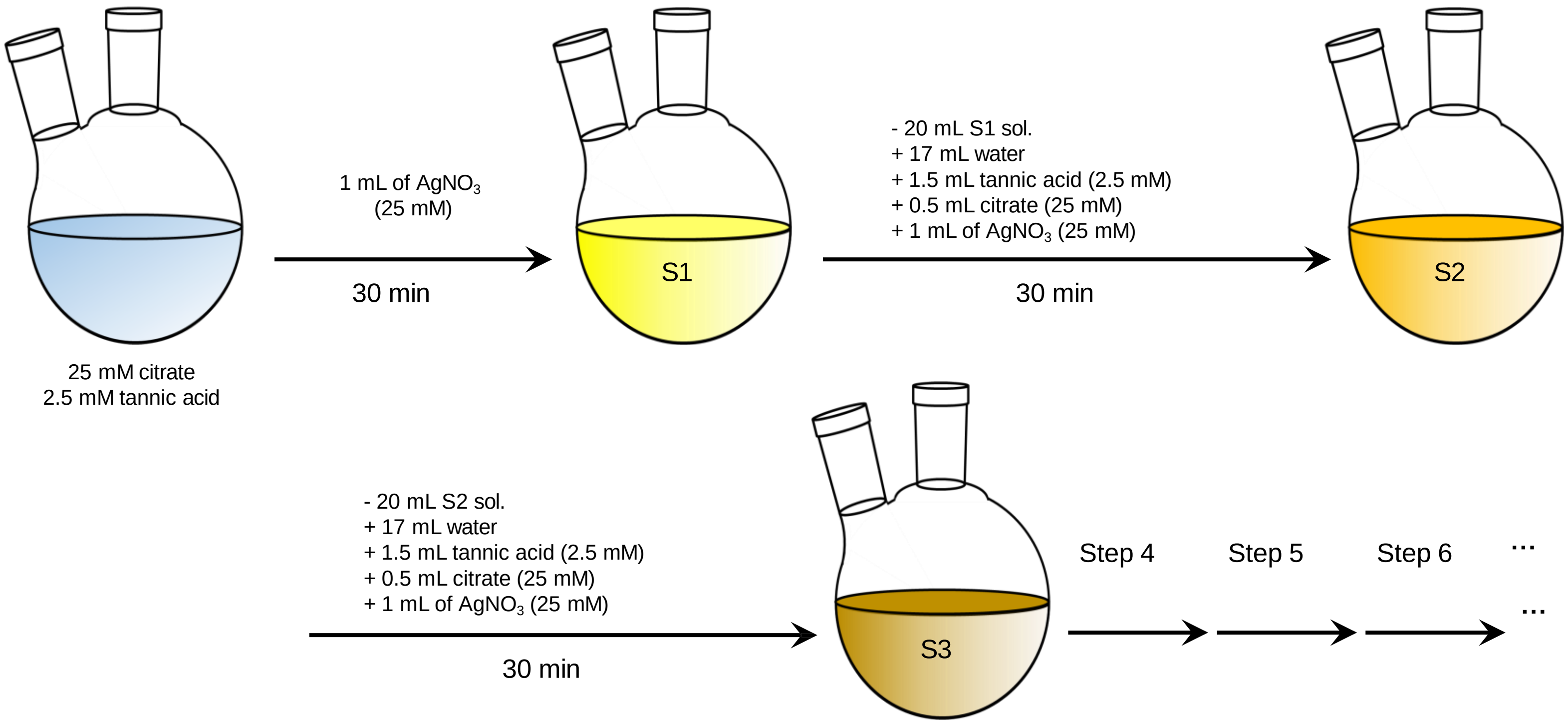
Classical Jablonski diagram for the free-space condition and the modified form in the presence of metallic particles, islands or radiative processes

- In the presence of the general dye, photochemical reactions decompose and cause a color of photosynthesis.
- Unlike normal organic light compounds, quantum dots are 100 to 1,000 times larger in absorbance coefficient than normal dyes and have higher quantum efficiency, which results in very high fluorescence.

¥ Chris D. Geddes et al. *Journal of Fluorescence*, Vol. 12, No. 2, June 2002

02 Experimental Method

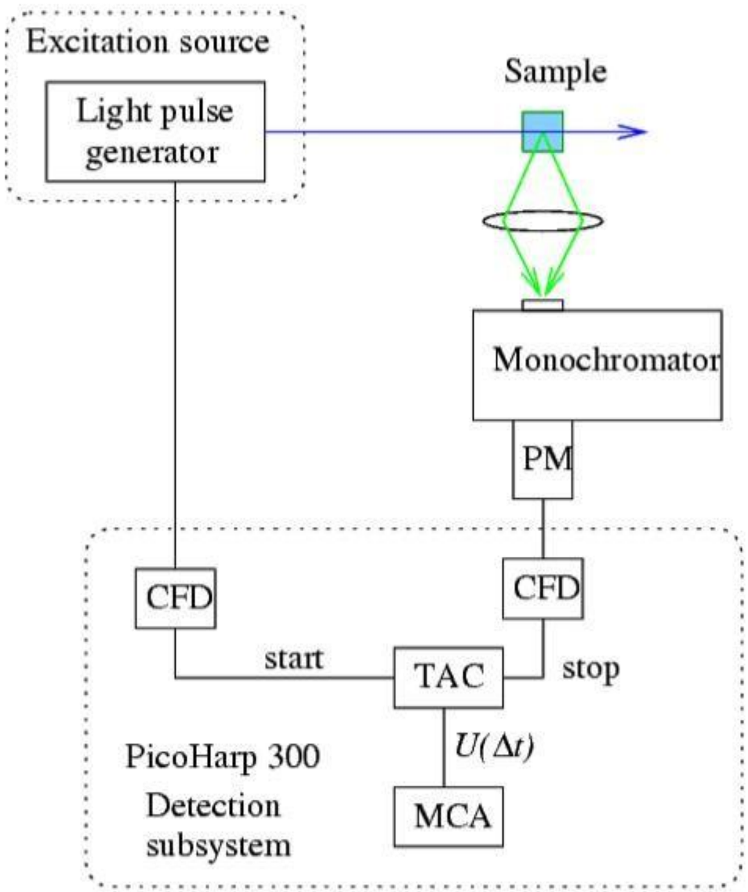
Specific protocols for Ag nanoparticle synthesis ▼



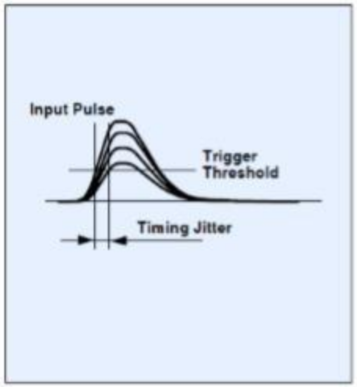
¥ Neus G. et al. *Chem. Mater*. **2014**, 26, 2836-2846,

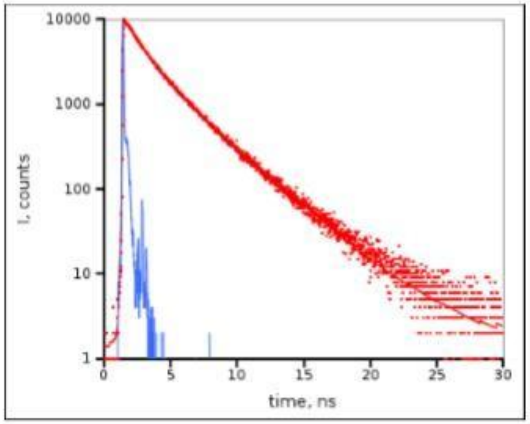
02 Experimental Method

Time-correlated Single Photon Counting (TCSPC) ▼



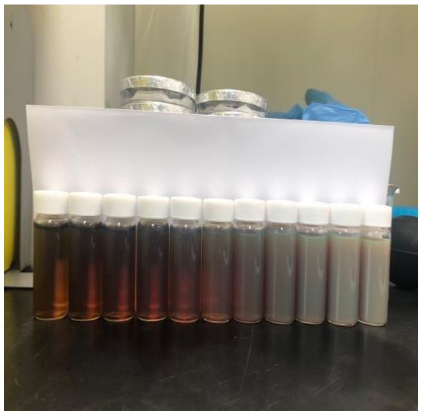
CFD; constant fraction discriminator





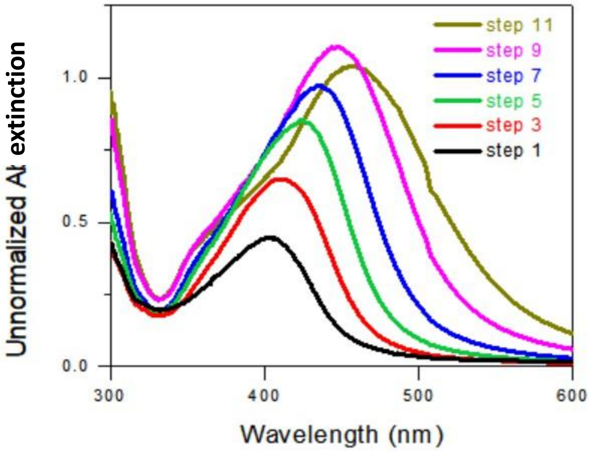
03 Results & Discussion

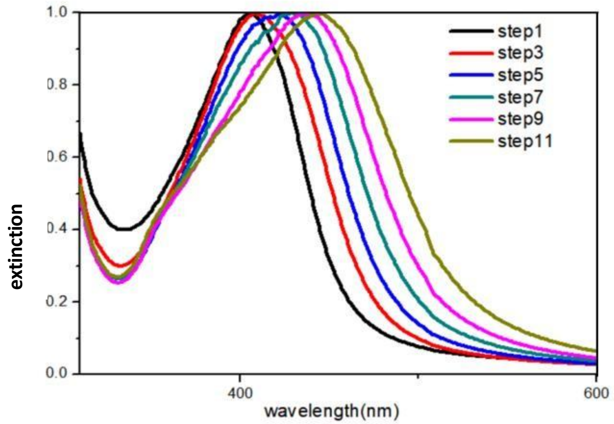
Color change in visible light & UV-Vis spectra ▼



color change in visible light

(chronological order from left to right)





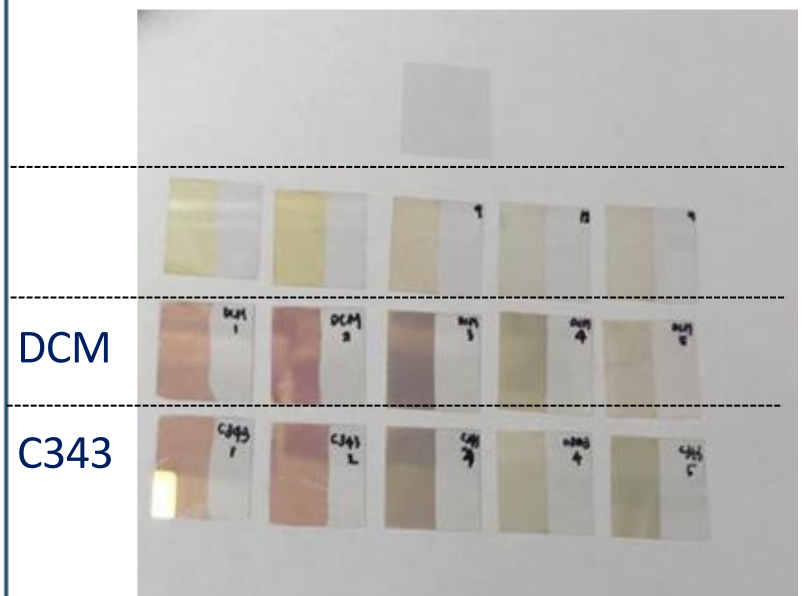
UV-Vis spectra of the samples in Figure 8
(Left-unnormalized, Right-Normalized)

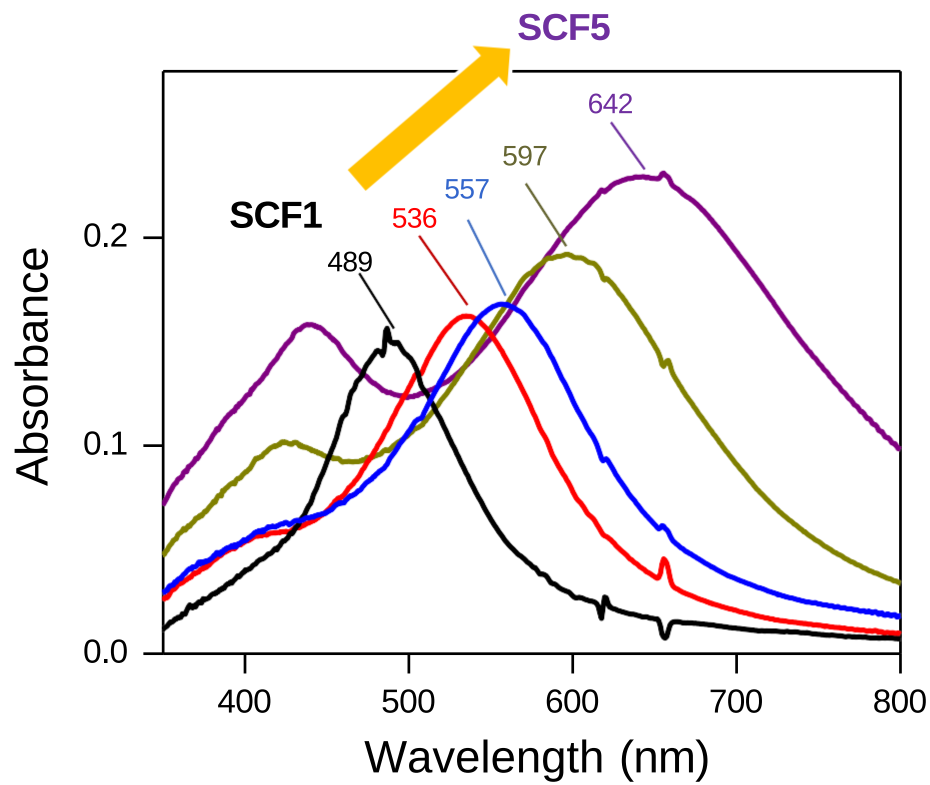
Sample	Step 1	Step 3	Step 5	Step 7	Step 9	Step 11
UV-Vis wavelength (nm)	402.9	411.1	424.2	433.9	447.0	456.8
Diameter (nm)	19.7	28.0	41.2	55.8	71.4	79.0

¥ Neus G. et al. *Chem. Mater*. **2014**, 26, 2836-2846,

03 Results & Analysis

Polystyrene (PS) coated Ag NPs arrays ▼

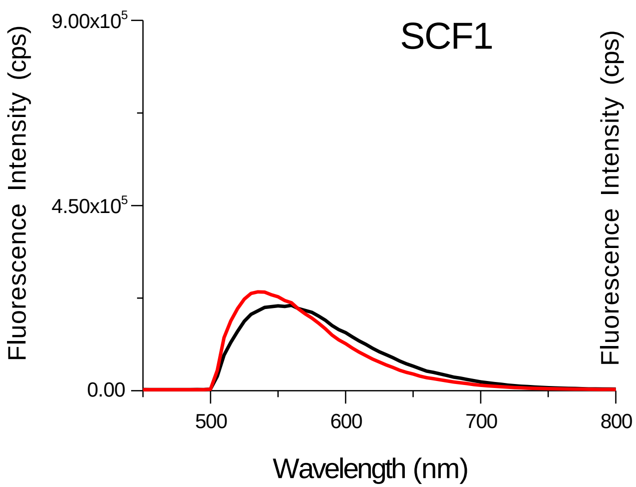


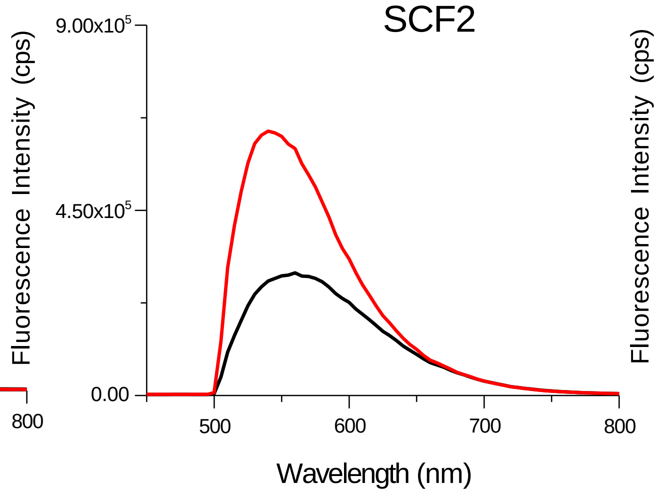


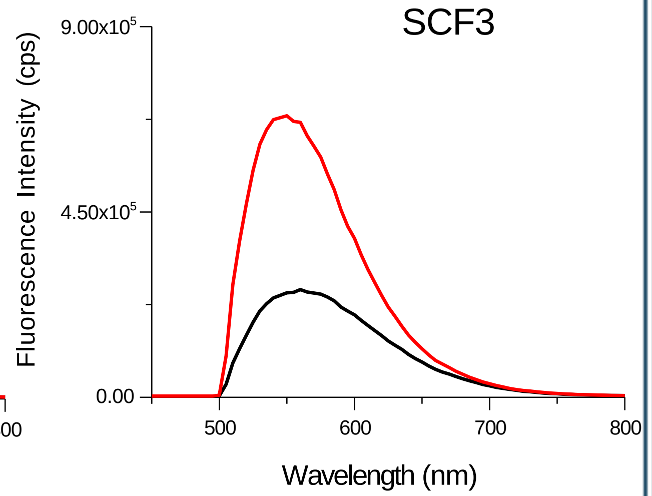
- Silver colloidal films (SCFs) coated by PS contatining DCM & C343 were fabricated for MEF study.
- The SPR bands are broadened and red-shifted as the size of Ag NPs increase.

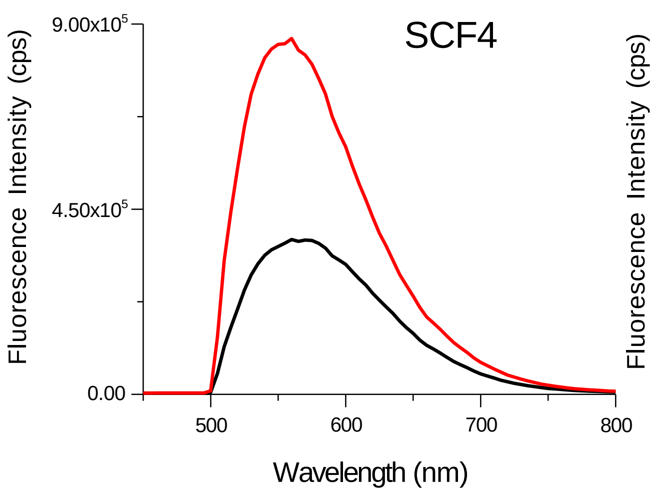
03 Results & Analysis

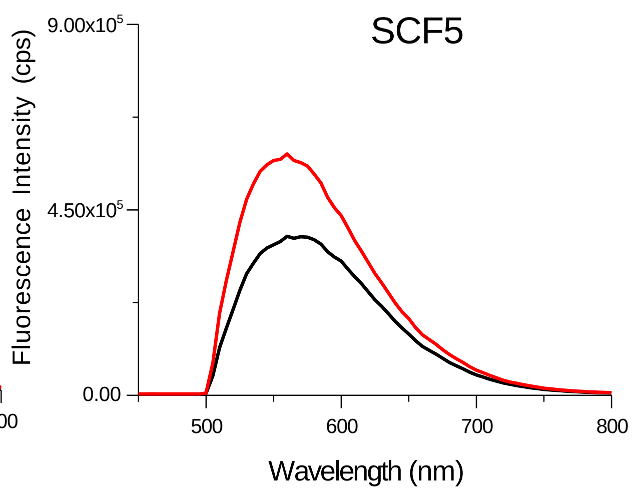
Fluorescence Enhancement of DCM molecules with SCFs









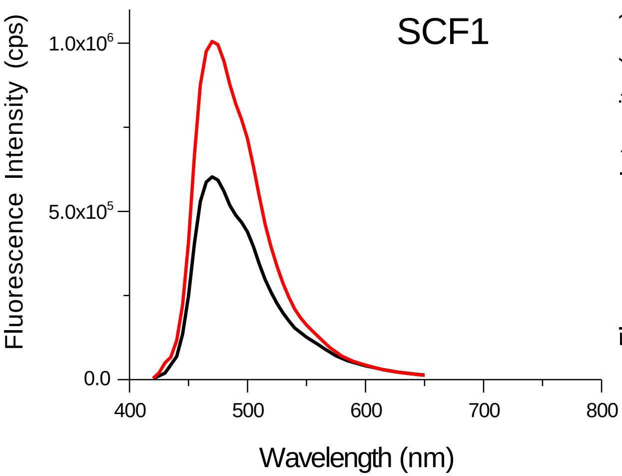


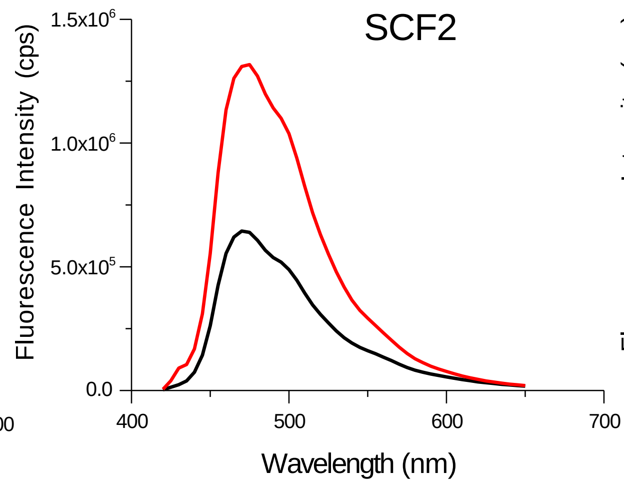
With	Enhancement Factor
SCF1	1.07
SCF2	2.04
SCF3	2.54
SCF4	2.27
SCF5	1.51

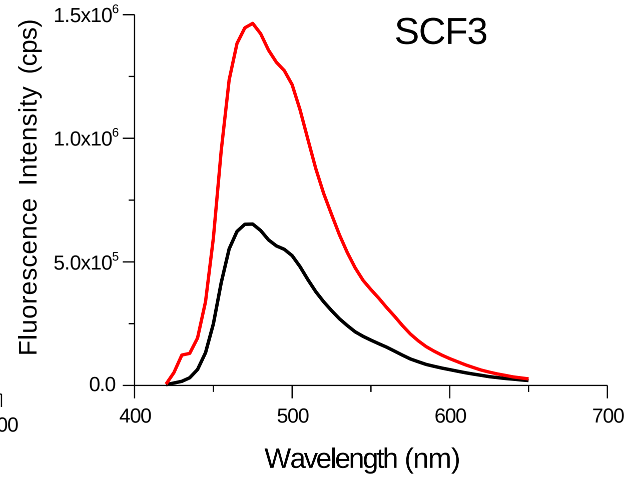
$$E.F. = \frac{I_{fluor}(SCFs\ surface)}{I_{fluor}(bare\ surface)}$$

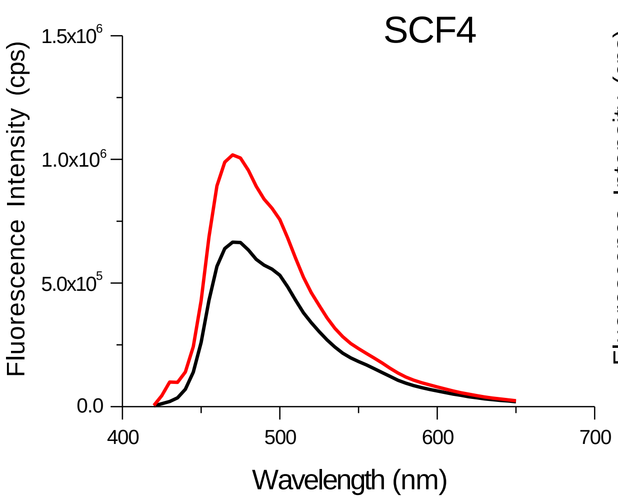
03 Results & Analysis

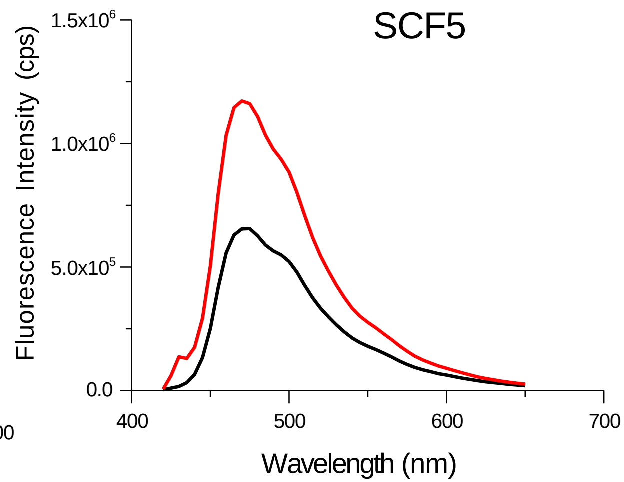
Fluorescence Enhancement of C343 molecules with SCFs









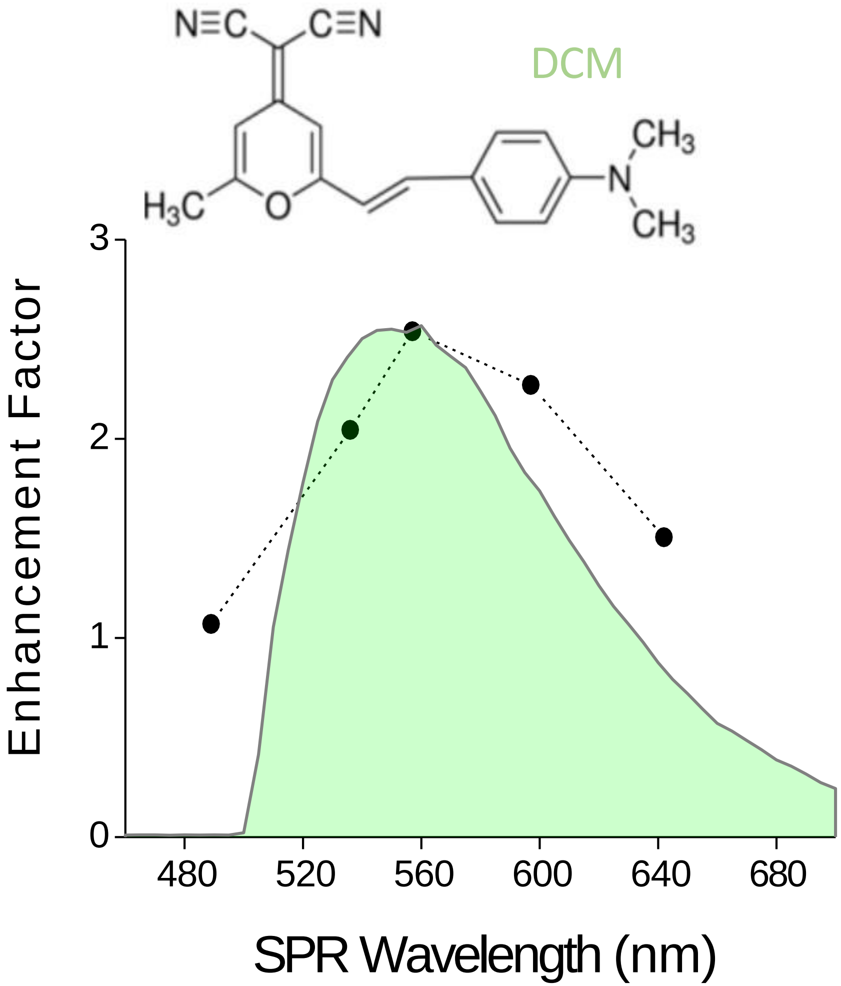


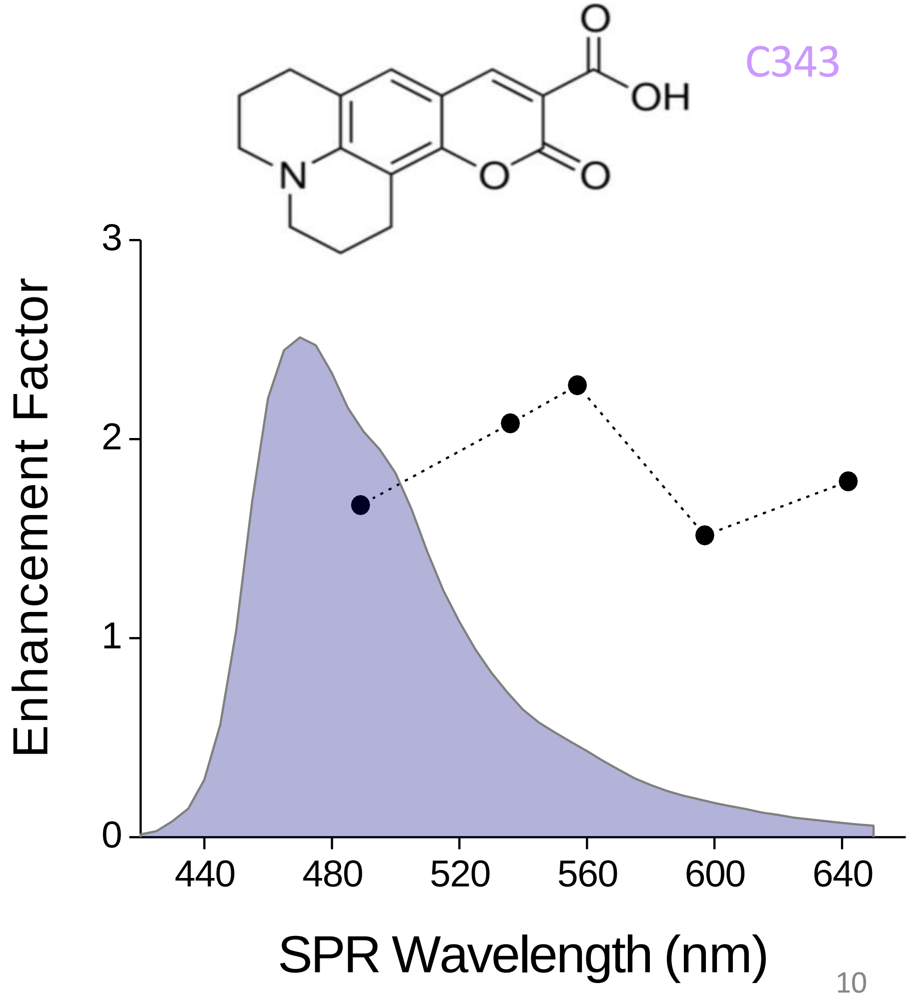
With	Enhancement Factor
SCF1	1.67
SCF2	2.08
SCF3	2.27
SCF4	1.52
SCF5	1.79

$$E.F. = \frac{I_{fluor}(SCFs\ surface)}{I_{fluor}(bare\ surface)}$$

03 Results & Analysis

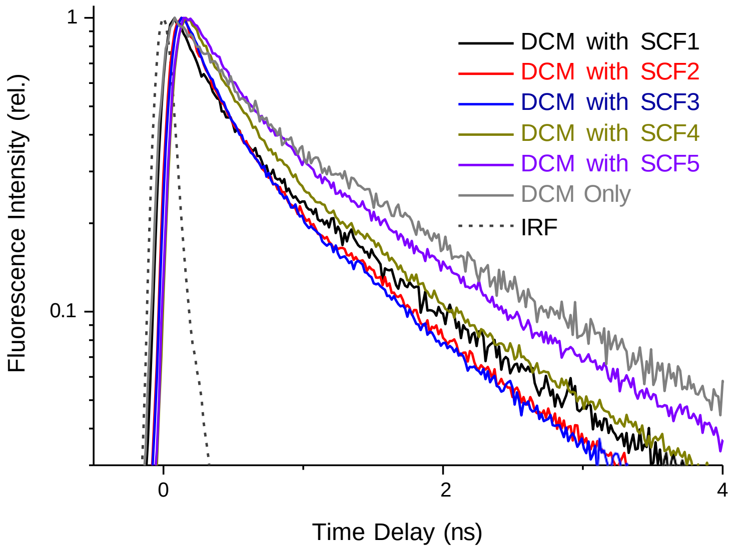
Fluorescence enhancement factors of DCM in thin PS films with SCFs as a function of maximum (dipolar) plasmon wavelength of the SCFs ▼

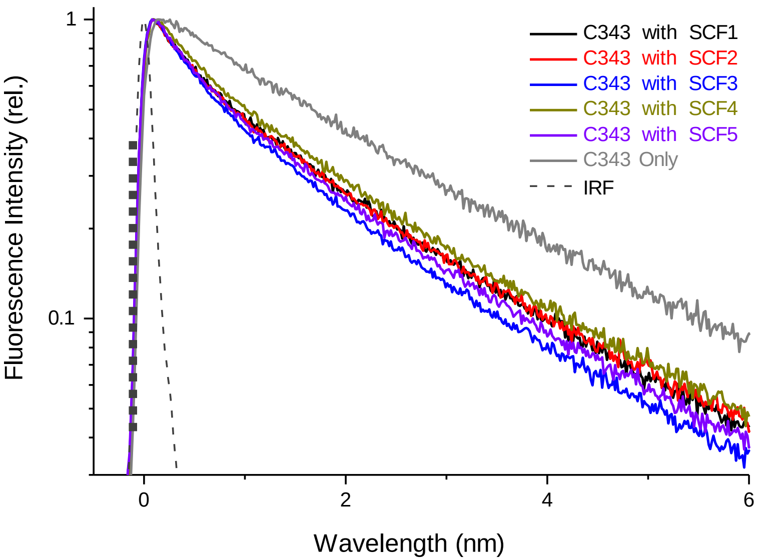




03 Results & Analysis

Time-resolved emission kinetics of DCM & C343 probed at 405nm in coated thin PS films with SCFs



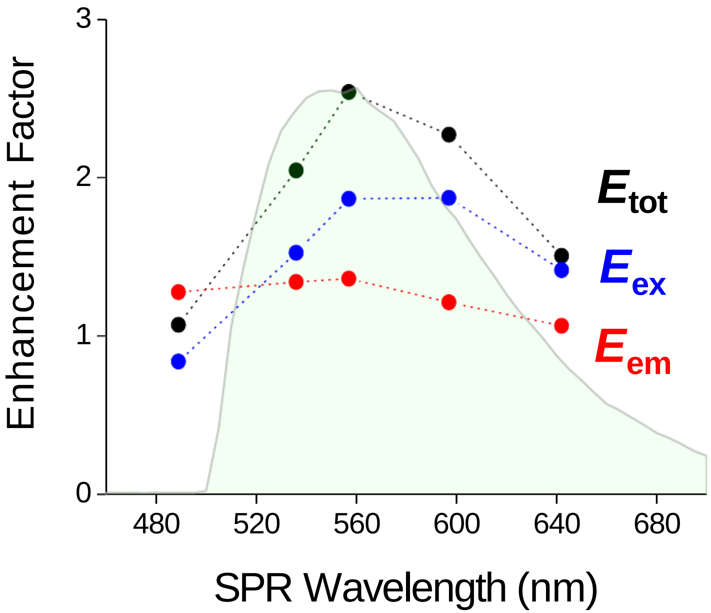


Sample	Lifetime (ns)	Enhancement Factor
DCM Only	1.59	-
DCM with SCF1	1.19	1.07
DCM with SCF2	1.11	2.04
DCM with SCF3	1.09	2.54
DCM with SCF4	1.30	2.27
DCM with SCF5	1.50	1.51

Sample	Lifetime (ns)	Enhancement Factor
C343 Only	2.36	-
C343 with SCF1	2.15	1.67
C343 with SCF2	2.25	2.08
C343 with SCF3	2.21	2.27
C343 with SCF4	2.04	1.52
C343 with SCF5	2.06	1.79

03 Results & Analysis

Quantum Yields of DCM & C343 probed at 405nm in coated thin PS films with SCFs ▼



$$Q_0 = \frac{\Gamma_0}{\Gamma_0 + k_{nr}} = \tau_0\Gamma_0$$

$$Q_m = \frac{\Gamma_m}{\Gamma_m + k_{nr,m}} = \tau_m\Gamma_m$$

$$\boxed{E_{em} = \frac{Q_m}{Q_0}}$$

Q_0 of DCM in PS = 0.47

Semi-empirical model

$$Q_0 = \frac{\Gamma_0}{\Gamma_0 + k_{nr}} = \tau_0\Gamma_0$$

$$Q_m = \frac{\Gamma_m}{\Gamma_m + k_{nr}} = \tau_m\Gamma_m$$

with SCFs

$$\Gamma_m = \frac{1}{\tau_m} - k_{nr} = \frac{1}{\tau_m} - \frac{(1 - Q_0)}{\tau_0}$$

$$Q_m = 1 - \frac{\tau_m}{\tau_0}(1 - Q_0)$$

$$\boxed{E_{em} = \frac{Q_m}{Q_0}} \quad \boxed{E_{ex} = \frac{E_{tot}}{E_{em}}}$$

	Lifetime (ns)	Quantum Yield, Q_m	Emission Enhancement Factor, E_{em}	Total Enhancement Factor, E_{tot}	Excitation Enhancement Factor, E_{ex}
DCM Only	1.59	0.47	-	-	-
DCM with SCF1	1.19	0.60	1.28	1.07	0.84
DCM with SCF2	1.11	0.63	1.34	2.04	1.53
DCM with SCF3	1.09	0.64	1.36	2.54	1.87
DCM with SCF4	1.30	0.57	1.21	2.27	1.87
DCM with SCF5	1.50	0.50	1.06	1.51	1.41

04 Conclusions

- Synthesized Ag nano particle in terms of size
- Fabricated homogeneous and well-dispersed polymer films with Ag nano particles
- Learned and arranged the TCSPC
- MEF tested of DCM & C343 dyes using several sizes of Ag nano particles prepared
- earned positive correlation between fluorescence enhancement with the extent of Surface Plasmon Resonance

05 Acknowledgement

- Advised by Professor **Yoonsoo Pang**

- **Femtosecond Spectroscopy Lab.**
  [(http://femto.gist.ac.kr)](http://femto.gist.ac.kr)
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