Bio-integrated Materials Science

2021 (Fall) Final Exam

(Posted Date: Nov. 3, 2021 (Wed.) 4:30 pm;

Submission Due: Nov. 5, 2021 (Fri) 5:00 pm *via* email to jhlee7@skku.edu)

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Student ID number ( )

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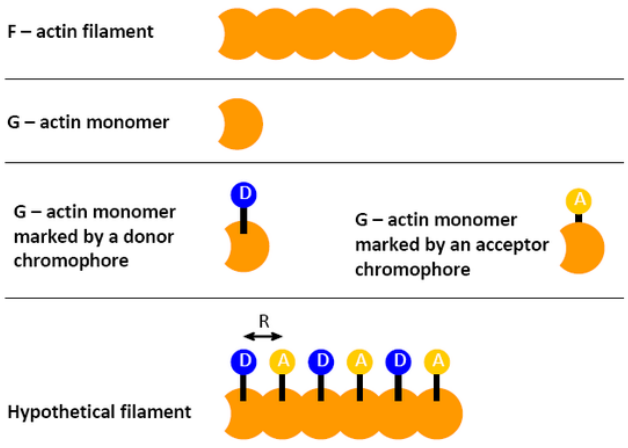
1. The FRET efficiency (*E*) is the quantum yield of the energy transfer transition; i.e., the fraction of energy transfer event occurring per donor excitation event. Within a point dipole-dipole approximation, the FRET efficiency can be related to the donar-acceptor distance via

$$E = \frac{1}{1 + (r/R_0)^6}$$

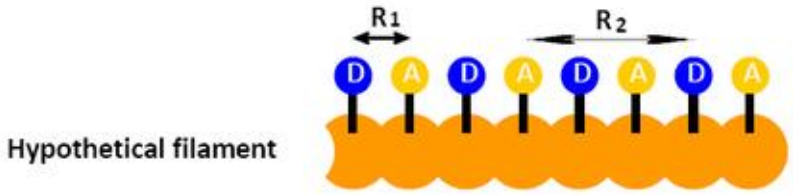
where r is the distance between donor and acceptor chromophores and R_0 is the characteristic distance (the Förster distance or Förster radius) with a 50% transfer efficiency.

Using the concept of FRET, solve the following two questions.....(20 points)

(1) The F-actin filament is composed by G-actin monomers. By attaching either a donor (D) or an acceptor (A) choromophore to the G-actin monomer and measuring the energy transfer efficiency to gauge the average distance between G-actin monomers in a F-actin filament (assuming that the monomers are well arranged in DADADADA.... sequence), and one finds that the average energy transfer efficiency is 23%. If the R_0 is 4.5 nm, what is the average distance between monomers in a filament.....(10 points)



(2) Based on the question (1), if the filament sequence is composed by 8 monomers in the order of D-A-D-A-D-A-D-A, how many kinds of efficiencies might be detected if the filament does not bend and the R_0 is big enough to see all of them?.....(10 points)



2. Enhanced permeability and retention (EPR) effect is one of the most popular strategy used for passive tumor (cancer) targeting. Explain how nanoparticles can specifically target tumor cells through this method. You can draw any diagram to explain this, if necessary..... (10 points)

3. Describe (i) what an upconversion luminescence is (5 points) and (ii) why upconversion luminescence is advantageous over conventional luminescence for imaging applications (10 points)….....(15 points)

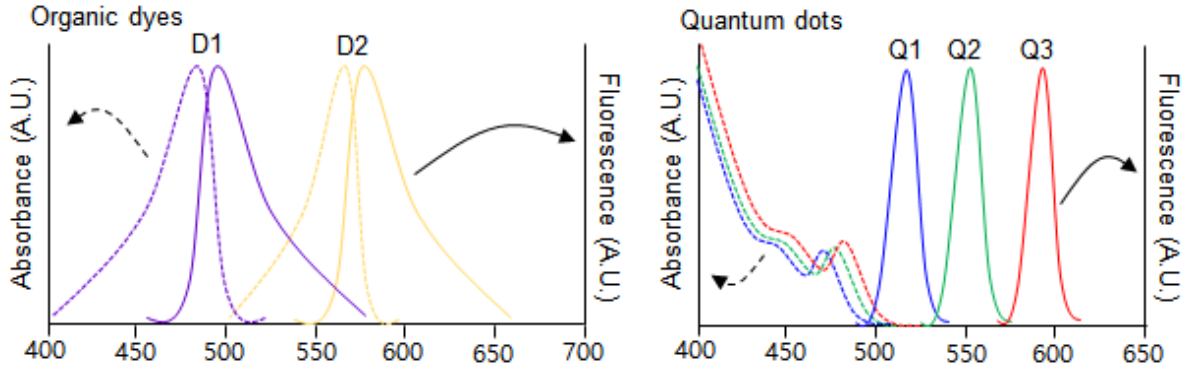
(i)

(ii)

4. Four sets of 13 nm gold nanoparticles were chemically functionalized with 4 different strands of DNA (DNA1, DNA2, DNA3, and DNA4) with thiol modification, resulting in DNA1-AuNP, DNA2-AuNP, DNA3-AuNP, and DNA4-AuNP. (1) Explain what will happen when DNA1-AuNP is mixed with DNA2-AuNP, DNA3-AuNP, and DNA4-AuNP, respectively, in a phosphate buffer with 100 mM NaCl. (15 points) (2) Explain which sample will show biggest color change (5 points) ?.....(20 points)

DNA1: 5′-ACTGGTATGCTA-SH-3′
DNA2: 5′-TGACCATACGAT-SH-3′
DNA3: 5′-TAGCATACCAGT-SH-3′
DNA4: 5′-SH-TAGCATACCAGT-3′

5. A researcher used 2 organic dyes (D1, D2) and 3 quantum dots (Q1, Q2, and Q3) with the absorbance and emission spectra as shown below for imaging. The colors emitted by each molecule is as follows; D1: purple, D2: yellow, Q1: blue, Q2: green, Q3: red. Answer the following questions.....(20 points)



(i) What colors will be observed if the researcher excite all of these molecules using a 450 nm laser?

(ii) What colors will be observed if the researcher excite all of these molecules using a 550 nm laser?

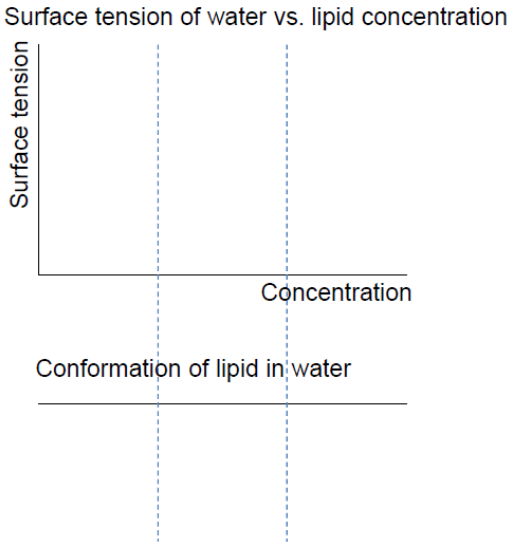
(iii) Organic dyes have narrow absorbance spectra and long emission spectra while quantum

dots have relatively broad absorbance spectra and narrow emission spectra. What is the critical advantage that can be achieved by using quantum dots rather than organic dyes based on this difference?

6. Please (i) define critical micelle concentration (CMC) (5 points) and (ii) describe CMC on the graph (5 points). Explain (iii) why lipids with lower CMC is preferred to form cell membrane (5 points) ..... (15 points)

(i)

(ii) Draw surface tension vs. lipid concentration graph and the conformation of lipid in water in each condition. Note where the CMC is on the graph.



(iii)

The End. Thank you very much!