

Investigating Energy Transfer and Dipole Coupling between Covalently Connected Gold Quantum Dots

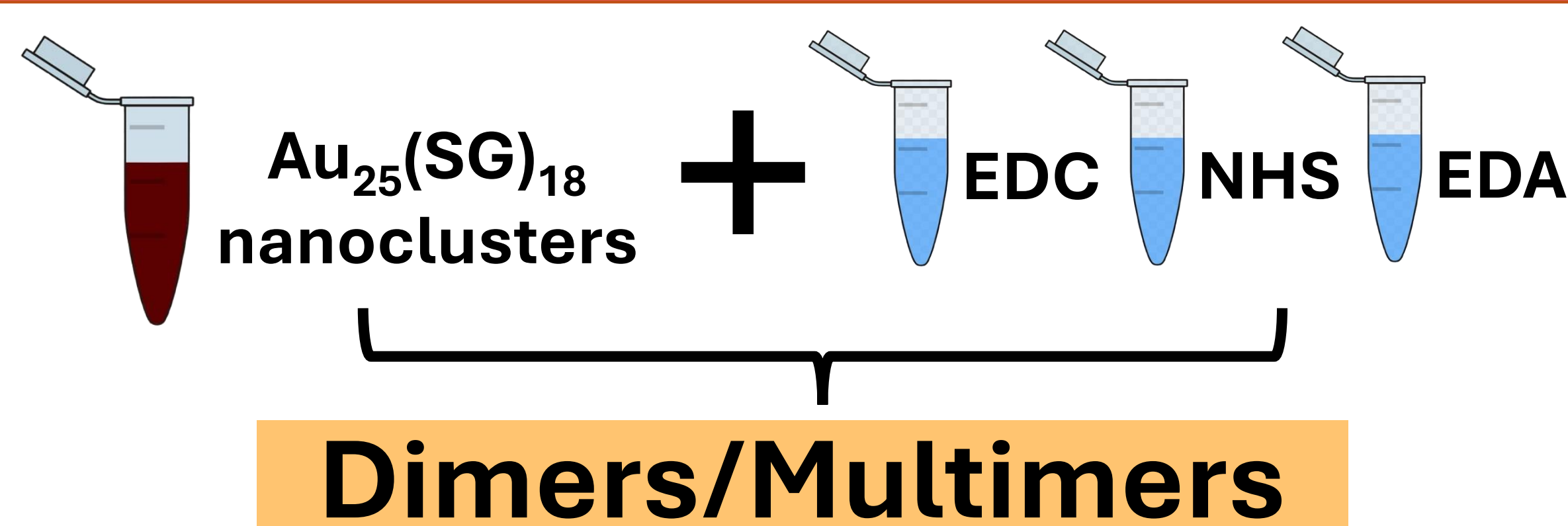
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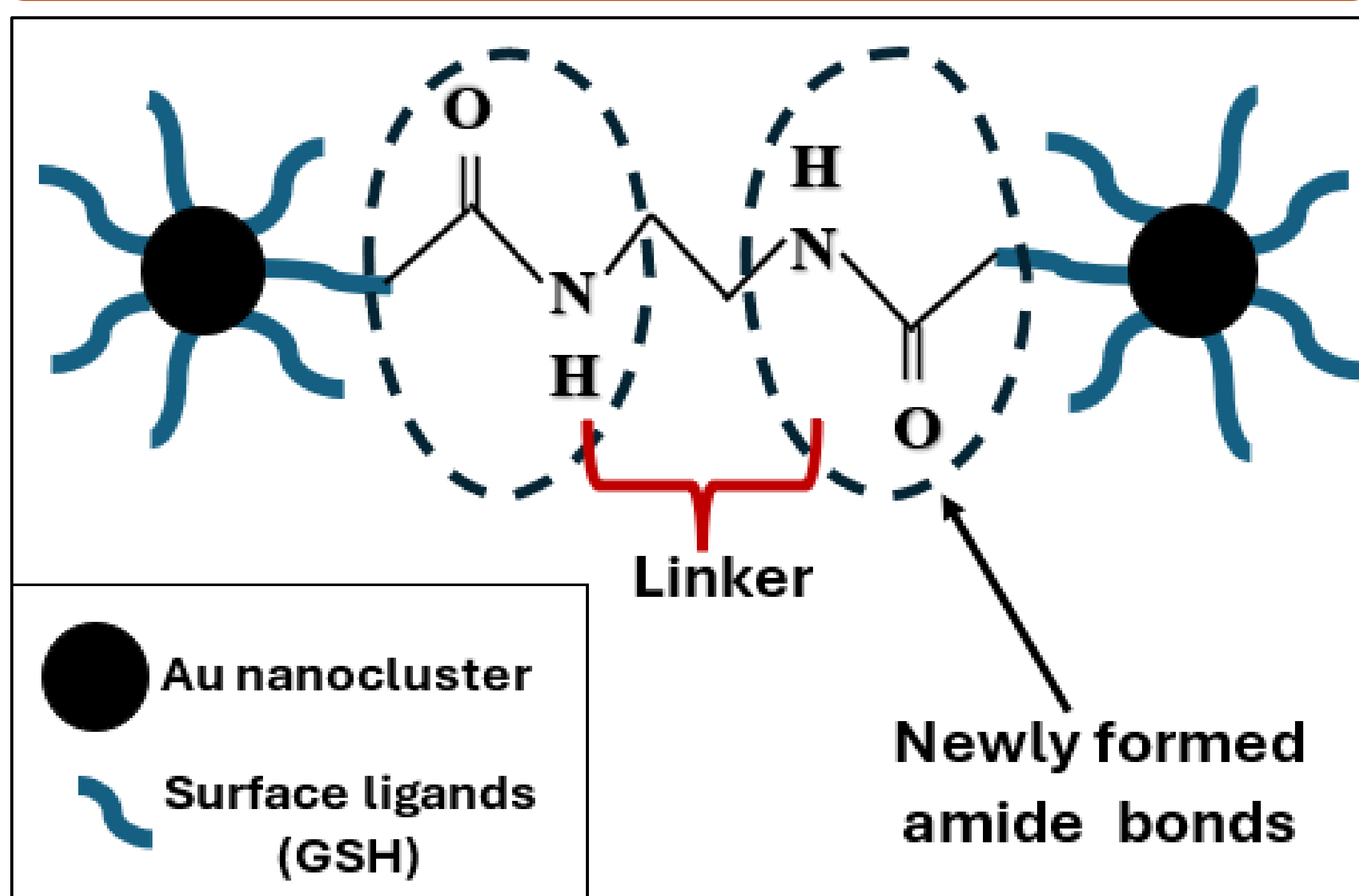
Introduction

- Atomically precise, quantum-confined gold quantum clusters/dots represent a unique class of **ultrasmall nanomaterials** with distinct electronic, optical, magnetic, and catalytic properties.
- Their potential applications in various fields such as **two-photon absorption/fluorescence, single-electron charging and improving optoelectronic efficiencies** have attracted significant research interests.
- Energy transfer and coupling due to adjacent dipoles could pave the way to **construct efficient optoelectronic systems that could reduce energy consumption** in modern devices abound.

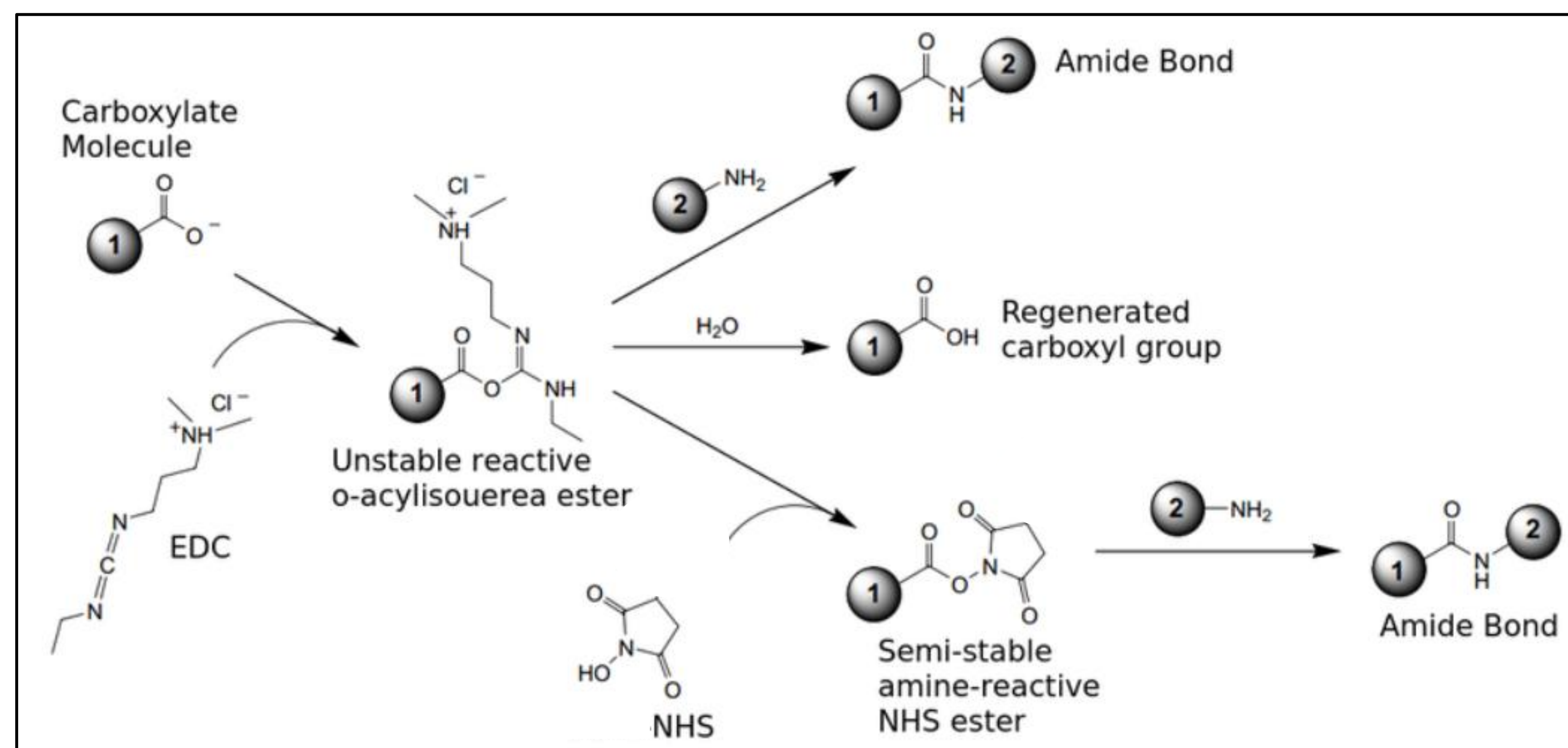
Coupling Reaction



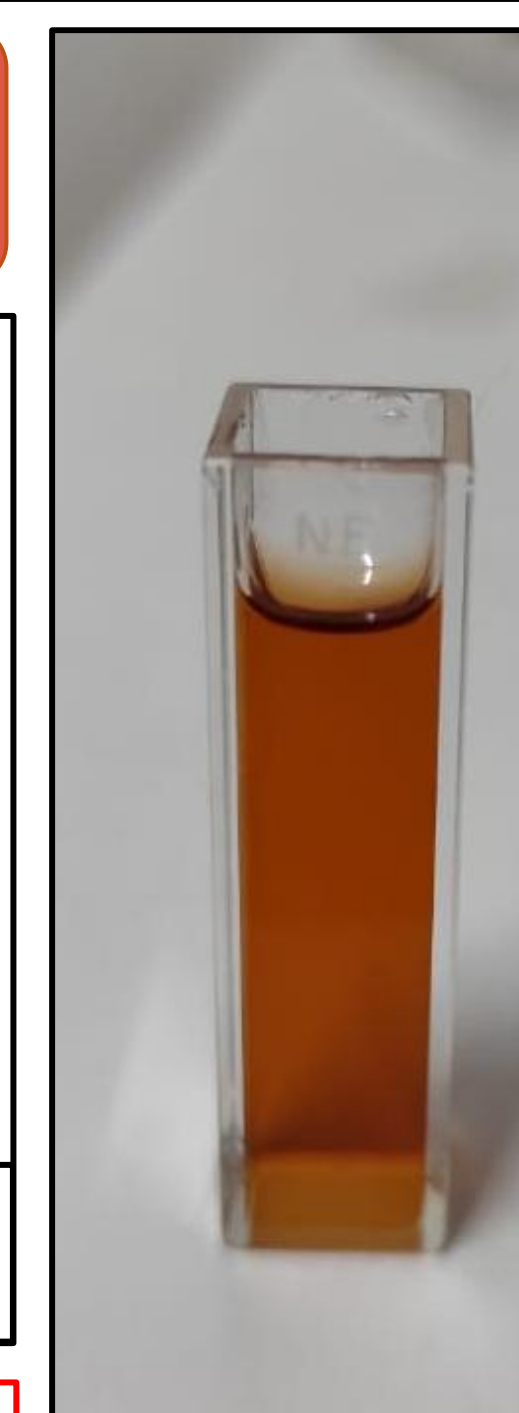
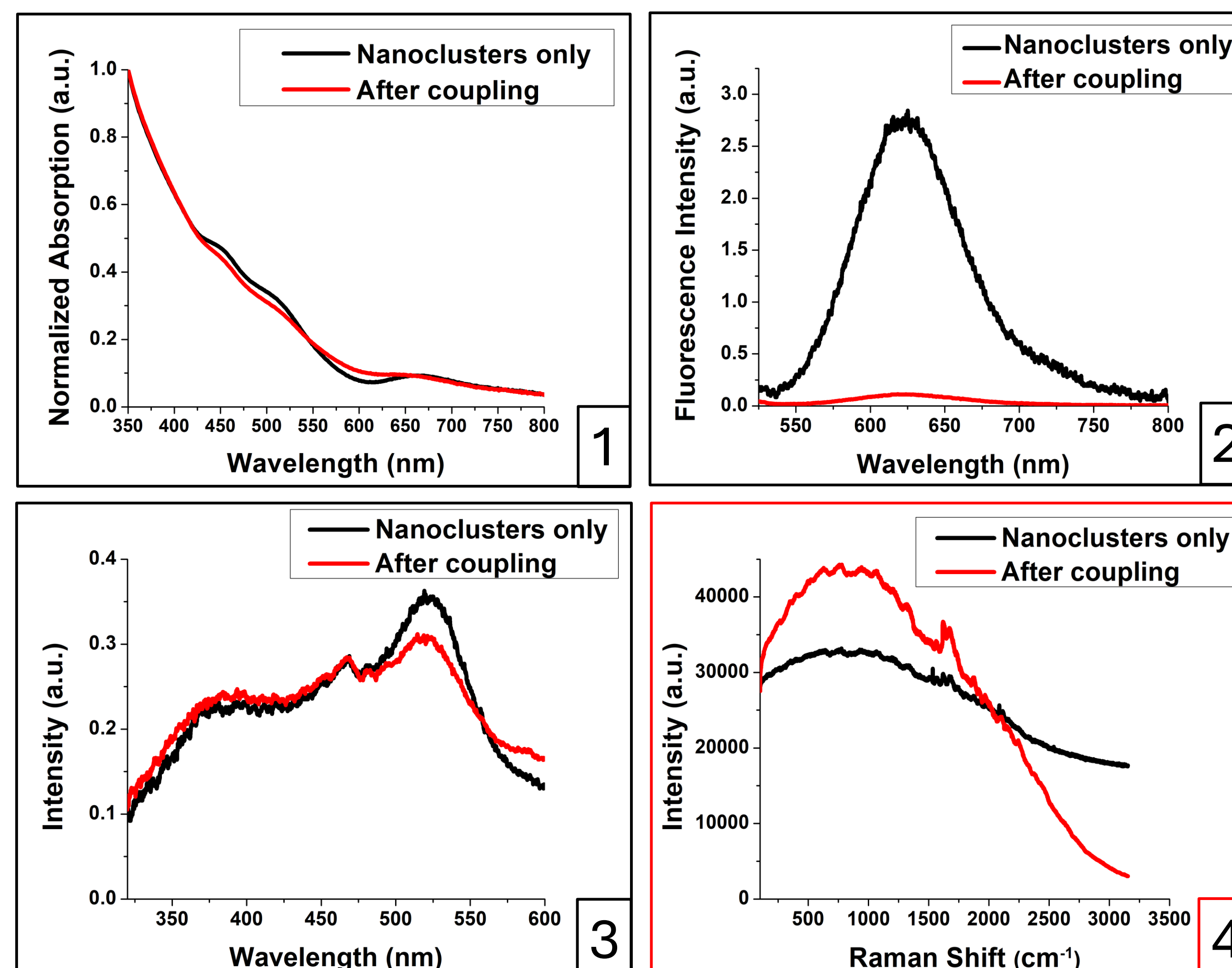
Model Dimeric Structure



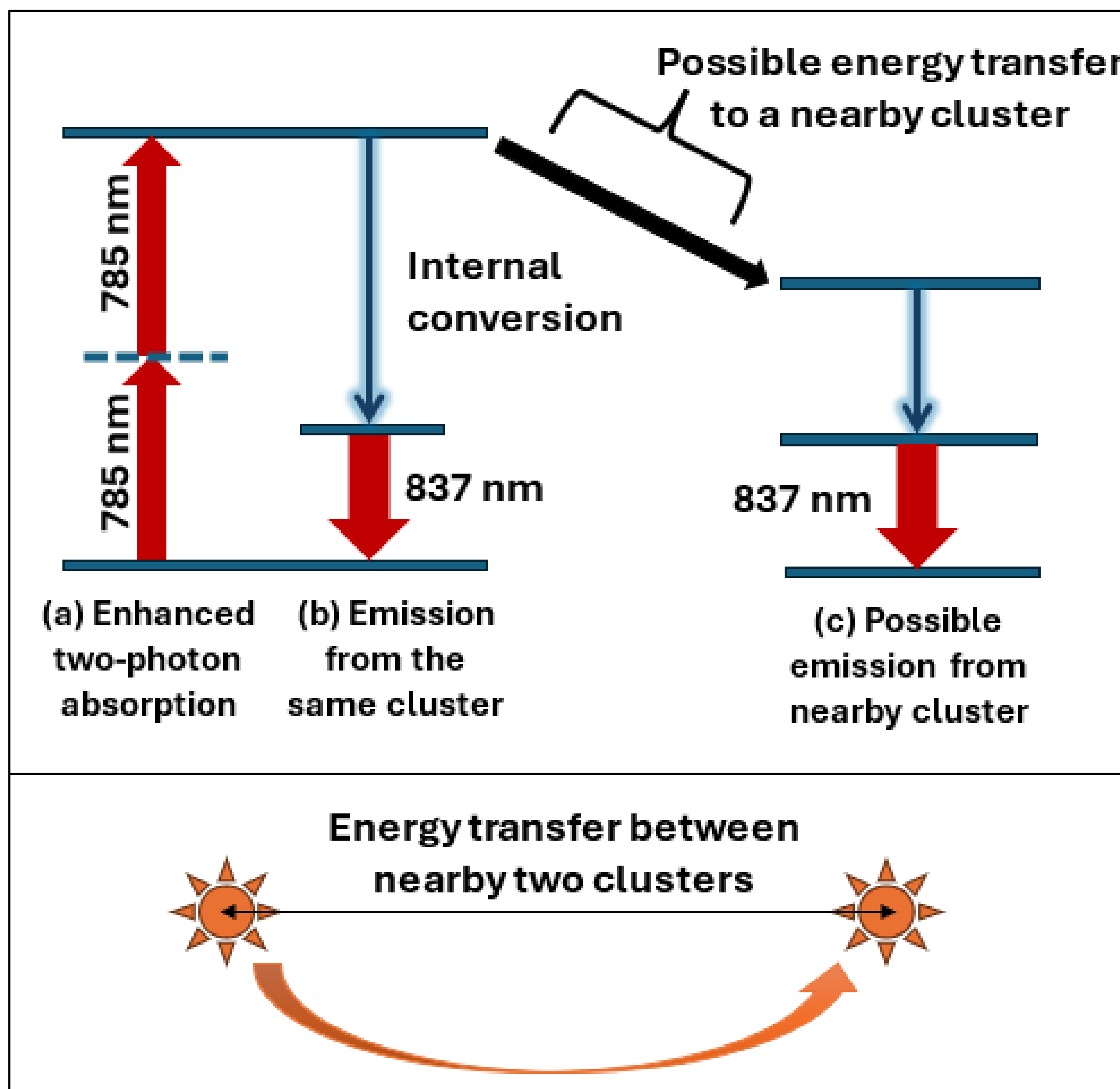
EDC/NHS Chemistry



Results



Proposed Energy Transfer Mechanism



Conclusion

- The results of the Z-scan experiments revealed the presence of reverse saturable absorption (RSA) and two-photon absorption (TPA) mechanisms, demonstrating their potential applications in optical limiting, multiphoton imaging, and photodynamic therapy.
- Hence, dimerization (coupling) of Au₂₅(SG)₁₈ quantum dots was carried out.
- This study provides a deeper understanding of the fundamental optical behavior of Au₂₅(SG)₁₈ dimers/multimers, including their atomically precise structures, discrete energy levels, and tunable HOMO-LUMO gaps, and highlights their potential for advanced optoelectronic applications that offer unique opportunities for sustainable energy technologies with low energy consumption.

Future Work

- To further confirm the formation of dimers, mass spectrometry studies must be carried out.
- To determine the excited state dynamics while understanding the exact energy transfer mechanism, time-resolved spectroscopy experiments must be performed.
- To determine the sizes of the covalently coupled dimers/multimers, high resolution TEM and STEM must be in cooperated.

References

- Abeyasinghe, N.; Kumar, S.; Sun, K.; Mansfield, J. F.; Jin, R.; Goodson, T. Enhanced Emission from Single Isolated Gold Quantum Dots Investigated Using Two-Photon-Excited Fluorescence Near-Field Scanning Optical Microscopy. *Journal of the American Chemical Society* 2016, 138 (50), 16299–16307. <https://doi.org/10.1021/jacs.6b07737>.
- Zhu, M.; Aikens, C. M.; Hollander, F. J.; Schatz, G. C.; Jin, R. Correlating the Crystal Structure of a Thiol-Protected Au₂₅ Cluster and Optical Properties. *Journal of the American Chemical Society* 2008, 130 (18), 5883–5885. <https://doi.org/10.1021/ja801173r>.

1. Steady State Absorption Spectroscopy
In between 425 nm – 550 nm wavelengths, the absorbance has decreased after the coupling. In between 550 nm – 650 nm wavelengths, absorbance has increased after the coupling.

2. Fluorescence Spectroscopy
As Figure 4 shows, the fluorescence intensities of the reaction mixture are much less compared to nanoclusters.

3. Excitation Spectroscopy
Although the shapes of the two spectra (positioning of the peaks) are the same, there are major differences in peak heights. Especially at 532 nm wavelength, the fluorescence intensity has been significantly reduced.

4. Raman Spectroscopy
In the reaction mixture, the intensity of the fluorescence peak (837 nm) has been increased. **The intensity related to the amide I band around 1650 cm⁻¹ has also been significantly increased.**