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J Material Sci Eng 2017, 6:5(Suppl)
DOI: 10.4172/2169-0022-C1-074

2nd International Conference and Exhibition on

Materials Science and Chemistry

July 13-14, 2017 Berlin, Germany

Single particle spectroscopic studies on two-photon photoluminescence of plasmon coupled gold nanotriangle dimers

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Surface plasmon resonance (SPR) coupling between adjacent metal nanoparticles in aggregated nanoclusters results in significant enhancements in many optical responses, such as fluorescence, surface enhanced Raman scattering (SERS) and two-photon photoluminescence (2PPL). Here, 2PPL properties of gold nanotriangle (Au NT) dimers with different spatial arrangements have been investigated on single particle level to understand their different plasmon coupling effects on 2PPL enhancement mechanism and explore the limit of maximum achievable enhancement factor. Compared to NT monomer, scattering spectra of both side-by-side and tip-to-tip coupled NT dimers are red-shifted by 101 nm and 175 nm, respectively with strong polarization dependence along their assembly axis, which can be understood in terms of plasmon hybridization theory. A close resemblance between scattering spectra and 2PPL spectra indicated SPR is the origin of observed 2PPL signal. 2PPL intensities of side-by-side and tip-to-tip dimers are enhanced by 1.0×10^3 fold and 2.6×10^4 fold respectively, compared to the NT monomer. Such a huge enhancement in tip-to-tip dimer is a combined effect of plasmon-coupling-induced red-shifted SPR band which has better overlap with the excitation wavelength and giant local electric field amplification due to the presence of sharp tips in inter-particle gap. The influence of sharp tips has been further demonstrated by comparing Au NT monomer and dimers with Au nanosphere (NS) monomer and dimer of similar dimensions. The 2PPL intensity of Au NT monomer is 20 times stronger compared to Au NS monomer, where as that of Au NT tip-to-tip dimer is 93.5 times stronger compared to Au NS dimer. All our experimental results show excellent agreement with numerically calculated integrated $|E/E0|^4$ results. These findings offer a deeper insight in fundamental understanding of plasmon coupling enhanced 2PPL properties and provide a platform for various sensing and imaging applications.

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The effect of synthesis conditions on enzymatic activity of metal ion incorporated enzyme based hybrid nanoflowers

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Enzymes are efficient and sophisticated biocatalysts. They evolve into unique biomacromolecules with three-dimensional structures consisting of a linear sequence of amino acids. Enzymes have received considerable attention owing to their unique properties, including high catalytic activity, stability, selectivity, low toxicity and water solubility. However, high cost of the enzyme purification procedures and the instability of the free enzymes in aqueous solution strictly limit their applications. To address these limitations of free enzymes, several immobilization methods have been developed. In general, immobilized enzymes show improved stability, making them efficient, reusable and economical. However, increased catalytic activity is generally limited due to mass transfer limitations between the enzyme and the substrate and conformational changes in the enzyme. Recently, Zare et al. has reported an encouraging breakthrough in enzyme immobilization with the synthesis of hybrid organic–inorganic nanoflowers have highly enhanced catalytic activity and stability. Therefore, there is a considerable interest in the synthesis and application of organic-inorganic hybrid nanoflowers. In this study, we synthesized organic-inorganic hybrid nanoflower by using laccase as organic components and Cu^{2+} as the inorganic component. We examined the effects of the synthesis conditions on the formation of Laccase-Cu^{2+} hybrid nanoflowers. FTIR, XRD, EDX spectroscopy and SEM were used to confirm the synthesized hybrid nanoflowers. To calculate the encapsulation yields of the hybrid nanoflowers, Bradford assay was used. We observed that by changing the synthesis conditions, including enzyme concentration, pH, and temperature, the morphology and enzymatic activity of the synthesized Laccase-Cu^{2+} nanoflowers were changed. In the synthesis phase, the pH influences petal density only, whereas enzyme concentration and temperature affect nanoflower size and petal density. But it should be noted that the solubility of $CuSO_4$ depends on the pH. The appropriate flower size and shape, enzyme content, and flower density are the critical factors for high enzymatic activity.

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