Guided Synthesis and Organization of Noble Metal Nanoparticles for Electrocatalytic and Biomedical applications

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Recently, the nanoparticles (NPs) of noble metals and their alloys have attracted enormous interest due to their unique properties and potential applications in the fields of photochemistry, electrochemistry, optics, magnetics, electronics, catalysis and biomedical applications [1-3]. The unique and attractive properties of nanoparticles are strongly dependent on the particle size, interparticle distance, nature of protecting organic shell and shape of the nanoparticles. Therefore, controlled growth, stabilization and surface characteristics of the nanoparticles are essential for specific application [1]. Template-mediated colloidal method using natural (such as DNA, bacterial surface layer proteins, ferritin, chaperonin, viruses, etc.) or artificial nanoarchitectures (e.g block copolymers, micelles, organic ligands, polymers, block copolymers, dendrimers, polyelectrolytes and ionic liquids, etc.) proved to be a highly attractive bottom-up approach to improve the quality of the NPs and control their functional properties. Designer polypeptides that adopt precise secondary structure, have emerged as interesting structural motifs for tailoring such NPs with great precision and have led to advances in device fabrication, photonics, catalysis, and sensor development [2].

In this research, we discuss the use of guided organization of a novel engineered bio-mimetic protein rec1-resilin [4-6] as a nanoreactor to synthesize and harness noble metal NPs (gold-Au, platinum-Pt etc) of controlled composition, particle size, aggregation and unique photo-physical and electrochemical properties. The detailed analyses of the NP-bio-conjugates using spectroscopic, microscopic and scattering techniques demonstrate the organizational pathways and unique electronic and photo-physical properties of the developed NP-rec1-resilin bioconjugates. Electrochemical tools were employed to confirm the electrocatalytic activity of the NPs. This multifunctional bio-conjugates so synthesized may have many potential applications including: (i) synthesis of highly stable catalytically active ultrafine (<<5nm) NPs using an aqueous environment under mild physiological conditions; (ii) co-assembly of rec1-resilin with NPs into ordered hybrid nanostructures that exhibit unique quenched emission of inherent fluorescence of rec1-resilin-useful for fluorescence quenching immunoassays; (iii) create multifunctional molecular entity through fusion of rec1-resilin to other functional biomolecular units/ligands before AuNP synthesis to introduce specific molecular recognition to the nanohybrids (such as biotinylation, where biotin portion of the modified protein binds to avidin with high affinity) and forms the basis for the recognition assay development).