# INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
# SHORT ABSTRACT OF THESIS


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## SHORT ABSTRACT


Engineering matter at the nanoscale to fine tune the properties associated with miniaturization has been a major challenge and opportunity for the physicists, material scientists, chemists and biologists across the globe. For example, fabrication of higher order ensemble nanostructures of zero-dimensional plasmonic and luminescent nanoscale particles via various chemical and physical means is likely to generate newer physicochemical properties, which could be of potential interest for various applications. In principle, solution state chemistry may offer us with a large repertoire of options for the attainment of such systematic design of plasmonic and luminescent nanoparticles and their higher order nanostructures. Furthermore, understanding and studying the reaction pathway towards the emergence of such ensembles is equally important.

The present thesis, therefore, adopts a two-step approach which exploits the synthetic advantage of plasmonic and luminescent nanoparticles employing rationally designed molecules, external stimuli *via* physical means and chemical reaction strategy to generate assembled nanostructures and further understand their reaction kinetic pathway for their potential utility in spectroscopy and biology. In this regard, **CHAPTER 1** gives a general overview of nanoscale metal particles and current state of the art development of higher order nano architectures of metal nanoscale particles and their future potential application. **CHAPTER 2** demonstrates a new way to study reaction of citrate stabilised gold nanoparticles (cit-Au NPs) in liquid medium *via* ligand (stabilizer) desorption method following a method of dialysis, to drive the assembly of AuNPs and further delineate the kinetic pathway of the reaction. Based on the reaction among the NPs and their aggregates, a model was further proposed to account for the observed kinetics. Taking a step further, **CHAPTER 3** further illustrates the effect of temperature on the reaction kinetics of the partially bare cit-Au NPs in aqueous medium in order to determine activation energy of the reaction and underlying reason towards barrier to activation based on a proposed model. However, control over the reaction of nanoparticles in the due course of assembly is necessary to achieve desired optical properties. Therefore, **CHAPTER 4** presents a new way to synthesize dimers of Cit-AuNPs employing a rationally designed metal complex of europium, which acted as a ligating unit to generate discrete dimers along with some population of trimers and oligomers in liquid medium. Importantly, the as-synthesized Au dimers served as potent SERS substrate showing enhanced Raman scattering signal of the Eu-complex trapped in the hot-junction of the nanodimer. Further, **Chapter 5** and **Chapter 6** deal with fluorescent probe of gold (Au) and copper (Cu) nanoclusters (NCs) and cover the engineering technique to fine tune their properties for the advantage of the same in bio-imaging and detection. Therefore, in **CHAPTER 5**, pH stimulus responsive CuNCs with aggregation induced emission (AIE) characteristics have been fabricated that upon internalisation into living cells (MCF-7) exhibited orange-red emission at $pH_i$ 4.5 whereas green emission was observed with time at $pH_i$ 7 and above *via* its AIE attribute. Further, the rate constant derived from the AIE kinetics followed inside living cells indicated 3-fold higher value for MCF-7 cells than that observed in HEK-293 cells thereby opening up a new strategy to study different cell lines. Next, in **CHAPTER 6**, a new strategy to develop a superior luminescent probe for cellular imaging have been demonstrated through biomimetic crystallization of zinc phosphate in peptide stabilised gold nanocluster (Au NC) assembly. The as-developed organic-inorganic hybrid nanostructures of zinc phosphate (AuNC-$Zn_3(PO4)_2$), allowed the clustering of peptide stabilised AuNCs in one platform leading to efficient internalization into the mammalian cells for convenient and enhanced fluorescence imaging than that with discrete as synthesized AuNCs only. In addition, it qualified as better imaging agent being resistant to protease and for its stability in human blood serum.