

**EXTENDED ABSTRACT**

**BIOGENIC SYNTHESIS OF NANOSTRUCTURES FOR  
SENSING, OPTOELECTRONICS, AND THERAPEUTICS**



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**By**

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We succeeded in synthesizing chlorophyll-rich CQDs via a one-step solvothermal method and in producing an efficient fluorometric sensor for the simultaneous detection of  $\text{Hg}^{2+}$  and  $\text{As}^{3+}$  ions. The ingenious strategy was to use *Plumeria* plant leaves as precursors for the synthesis of CQDs. The synthesized CQD160 showed excellent  $\text{p}^{\text{H}}$ , salt and storage stability. In addition, fluorometric sensing showed high sensitivity and selectivity towards  $\text{Hg}^{2+}$  and  $\text{As}^{3+}$  ions. The detection limit (LOD) for  $\text{Hg}^{2+}$  and  $\text{As}^{3+}$  metal ions in the DI solution was reported to be 0.99 nM and 12.15 nM, respectively. The proposed probe showed significant results in a real water system and estimated the  $\text{Hg}^{2+}$  ion concentration to be 3.62  $\mu\text{M}$  in Powai Lake. The fluorescence lifetime measurements showed that the quenching of fluorescence upon addition of  $\text{Hg}^{2+}$  ions was due to a combination of static and dynamic quenching mechanisms. We were able to determine the dynamic quenching constant  $K_{\text{D}}=8.0 \times 10^4 \text{ M}^{-1}$  for  $\text{Hg}^{2+}$  ions. This high value of  $K_{\text{D}}$  indicates high efficiency of fluorescence quenching. To understand the effects of the metal ions on the fluorescence of the CQD160, we investigated the interaction of the metal ions with the CQD160 using X-ray photoelectron spectroscopy. We observe that the  $\text{Hg}^{2+}$  and  $\text{As}^{3+}$  ions are binding to oxygen functional groups present on the CQDs which alters the fluorescence of the CQDs. The CQD160 were found to be biocompatible and less cytotoxic, providing excellent bioimaging in the blue, green, and red regions. We also used these CQD160 to detect  $\text{As}^{3+}$  and  $\text{Hg}^{2+}$  ions in human cells NIH-3T3 and also performed a hemolysis study.

We have also synthesized gold nanoparticles (GNPs) using extracts of *Tulsi* and *Vinca*. The mixed of *Tulsi* and *Vinca* extract for GNPs caused significant breast cancer tumour regression in mice model. The physical properties were evaluated using UV-VIS, TEM, XRD, PL, FTIR, XPS, Zeta and DLS. The synthesized GNPs have different shapes and sizes with higher crystallinity. The GNPs also have emitting properties ranging from blue to green at 280 nm excitation and absorb light at 280 nm and  $555 \pm 15$  nm. FTIR and XPS confirmed the presence

of the different functional groups on the surface of the synthesized GNPs. These decorated GNPs showed that the zeta potential values for T-gold, V-gold and T+V-gold were -28.5 mV, -22.3 mV and -32.4 mV, respectively. The broad peak in the dynamic light scattering (DLS) measurements typically arises from the presence of particles with a broad size spectrum or the coexistence of multiple populations of particles in the synthesized samples. The inhibitory effects of T-Gold, V-Gold, and T+V-Gold on the growth of 4T1 cells were evaluated using the MTT assay. The combination of T+V-Gold exhibited higher cytotoxicity compared to bare T-Gold and V-Gold, which resulted in the rapid release of anti-cancer metabolites that easily reached the cell organelles, thereby exhibiting cytotoxicity but also showed less cytotoxicity on NIH-3T3 cells. In liver, control and GNPs injected mice exhibited minimal lesions, corresponding to normal liver. T-Gold, V-Gold, and T+V-Gold showed negligible toxicity. T+V-Gold nano-formulation demonstrated the better regression of tumour when compared to the untreated 4T1-tumour bearing mice treated with PBS. To understand the underlying mechanism of the reduced tumour burden post treatment with T-Gold, V-Gold, and T+V-Gold NPs, the anti-oxidant pathways altered in cancer, such as glutathione family including GST, GSH, as well as SOD in serum. NO and LDH showed increased oxidative stress that was well supported by the mechanism of tumour suppression in tumour-bearing animals after the administration of the formulation. The concentration of SOD enzyme was lower in tumour tissues under different conditions compared to normal tissues, indicating a potential role of SOD in preventing oxidative damage in tumours. The T+V-Gold treatment may have a positive effect on the GSH and GST activity in tumour tissue samples, which could potentially help reduce the risk of cancer progression. In summary, the T-Gold, V-Gold, and T+V-Gold nanoparticles demonstrated good stability, DPPH scavenging potential, cytotoxicity, and in vivo anti-cancer potential in 4T1 tumour bearing mice.

Another work to have synthesized fluorescent functionalized carbon quantum dots (CQDs) by a facile one step hydrothermal method at 160°C for 8hrs using *Plumeria* plant leaves as precursor and  $Tb^{3+}$  ions as a surface passivator. The prepared doped CQDs exhibit excitation-dependent PL emission and obtained strong peaks at 493, 554, 590, and 624nm, respectively, is due to doping of  $Tb^{3+}$  ions. The CQDs and CQDs+ $Tb^{3+}$  ions have amorphous in nature with narrow size distribution and show high fluorescence quantum yield (26.33%, and 39.49%). The additive agent  $Tb^{3+}$  has engaged in reaction following the synthesis of the CQDs, as shown by the structural characterisation of the CQDs studies. We paired the single CQD phosphor film with the UV chip to create a WLED that emits cool white light with a CIE coordinate of (0.33, 0.34), a corresponding colour temperature of 4995K with CRI 84.2, and favourable Electroluminescence behaviour as a white-light converter for white LED.

Finally, boron nitride quantum dots (BNQDs) were synthesized from boron nitrate nanopowder through a hydrothermal process. The BNQDs exhibited excellent sensing behavior towards p-nitrophenol (PNP) with a low detection limit of about 7.91 pM. Time-resolved photoluminescence studies confirmed the high selectivity and sensitivity of the BNQDs for PNP sensing. The cost-effective and environmentally friendly synthesis approach presented in this study contributes to the development of nanomaterial-based sensing technologies with potential applications in environmental monitoring.

Overall, our versatile approach in the synthesis and characterization of nanomaterials demonstrates their versatility for sensing and therapeutic applications and highlights their potential impact on various scientific and technological fields.

