# Novel Hybrid Nanocomposites based on Au Nanoparticles Decorated Soot Carbon Nanoparticles for Electroanalytical Sensors

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**Significance and Relevance**

Secondary raw materials such as soot carbon nanoparticles (NPs) were decorated with Au NPs by sustainable chemical colloidal approaches, resulting in original hybrid nanocomposites. The structural, spectroscopic, morphological and electrochemical properties of the novel nanocomposites were characterized, and their electroanalytical properties were tested in the detection of $H_2O_2$ and diclofenac (DFC) drug.

*Preferred and 2nd choice for the topic: Green chemistry and biomass transformation, renewable resources conversion*

*Preferred presentation*: Oral preferred or Short Oral

**Introduction and Motivations**

Soot carbon NPs, a by-product from incomplete hydrocarbon combustion, have garnered significant attention due to their adverse effects on climate, environment and human health [1]. However, their unique properties, such as a high surface to volume ratio, excellent electrical conductivity and remarkable thermal stability, have prompted interest in their use as a cost-effective graphitic alternative to commercial graphene derivatives. This potential upcycling into high added value nanocomposites offers a sustainable pathway for innovation in materials science [2]. Among various approaches, decorating soot NPs with Au NPs using solution-based chemical approaches, a strategy that has never been explored so far, can be effective, yielding hybrid materials with enhanced surface area, electrical conductivity and electrocatalytic performance. While extensive research exists on similar hybridization with carbon nanotubes, carbon black and graphene derivatives [3], very few studies have explored the decoration of soot carbon NPs with inorganic NPs [2]. In this work, a sustainable colloidal chemical approach was implemented to decorate soot carbon NPs with Au NPs, for the detection of $H_2O_2$ and DFC, a pharmaceutical water contaminant with serious human health and environmental concerns.

**Results and Discussion**

Soot carbon NPs were synthesized using a nitrogen-quenched ethylene diffusion flame, producing graphitic NPs of tens of nm in size, which formed fractal-like aggregates (Figure 1A). To graft oxygen-based functionalities at their surface, the soot NPs were treated with nitric acid under reflux conditions. This treatment preserved their morphology and graphitic properties, while grafting carbonyl and carboxylated groups (data not shown), which acted as coordinating sites for the *in situ* synthesis of Au NPs. Two methods were used to reduce the Au precursor ($HAuCl_4 \times 3H_2O$) onto the soot NPs: i. spontaneous galvanic displacement (Figure 1B), and ii. citrate assisted reduction (using $C_6H_5O_7Na_3 \times 2H_2O$) (Figure 1C). The citrate method was optimized by systematically varying the

citrate:Au precursor molar ratio and soot NPs:Au precursor w/w, and concomitantly investigating morphology of the resulting hybrid nanostructures. The Au NPs heteronucleated and grew on the oxygen-functionalized sites, with higher coating density achieved via citrate reduction, leading to the formation of an Au aerogel [4] supported on the graphitic carbon scaffold (Figure 1C). The soot NPs were characterized by cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS), before and after decoration with the Au NPs. The CV results indicated an increase in the $Fe(CN)_6^{3-/4-}$ redox peaks compared to those observed at the bare SPCE electrode, and EIS data revealed a significant enhancement in the electrocatalytic activity and faster electron transfer kinetics at the electrodes modified with the soot NPs and soot/Au NPs (data not shown), underscoring the potential of the developed materials for electroanalytical applications. Preliminary tests for $H_2O_2$ and DCF detection showed promising results. The soot NPs demonstrated an improvement of the electrode performance in $H_2O_2$ (Figure 1D) and DCF detection (Figure 1E), that further enhanced in the soot/Au NPs sample synthesized with citrate. For $H_2O_2$, a linear limit of detection of 71 µM (sensitivity of 0.28 µA/mM) was reached in the soot/Au NPs sample synthesized by spontaneous reduction of the Au precursor (Figure 1D). For DFC, a shift in its characteristic oxidation peak towards lower potentials was observed at both the soot/Au NPs modified electrodes (Figure 1 E). These findings underscore the potential of the soot/Au NPs hybrid nanocomposites in the development of enzymatic biosensors, for clinical diagnostics, oxidative stress assessment and electrocatalytic sensors.

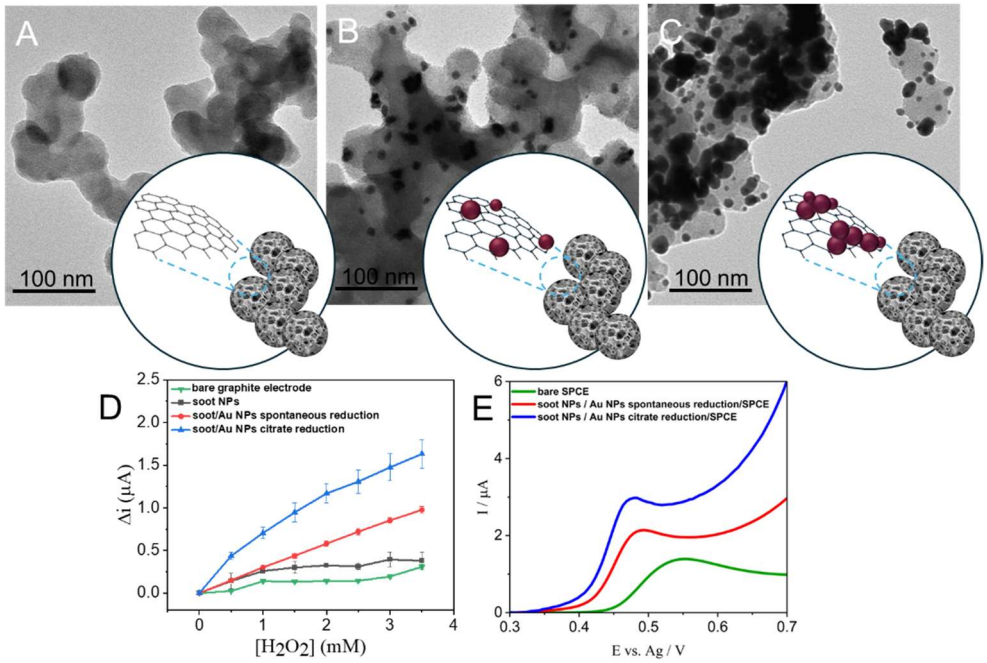


**Figure 1**. TEM micrographs of soot NPs A) pristine and decorated with Au NPs by spontaneous B) and citrated assisted reduction C). D) Chronoamperometric detection of $H_2O_2$ and E) DPV measurements of 10 µM DCF in 0.1M PBS at the investigated electrodes.

**References**


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