X Workshop on Novel Methods for Electronic Structure Calculations

Core-shell nanohybrids (Au/Graphene): Spontaneous synthesis, characterization and potential application in biosensors.

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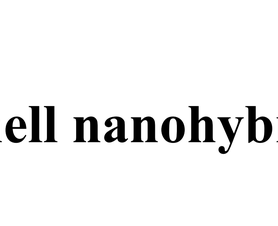
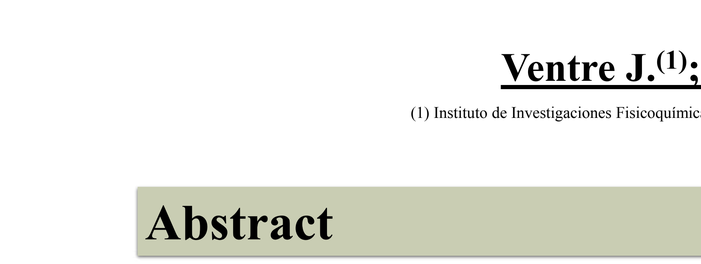
Abstract

In recent years, research on hybrid nanomaterials based on graphene has intensified because of their outstanding optical, electronic, and catalytic properties. It has been reported that the assembly of materials based on Au and C improves their properties for applications related to optoelectronics and biosensors to detect mainly glucose. In this work we demonstrate that the mixture of $HAuCl_4$ with graphene quantum dots (GQDs) at room temperature and pH 6-7 leads to the spontaneous formation of core-shell type Nanohybrids (NHs). The product obtained was characterized by high resolution transmission electron microscopy (HRTEM) where gold nanoparticles coated by a graphene shell of 1 nm (3-4 layers) with an average size of 8.6 nm, monodisperse and without agglomerations, were observed. The chemical composition of the core and the shell was determined by X-ray photoelectron spectroscopy (XPS). Optical characterizations were also performed by UV-vis and fluorescence spectroscopy, where the presence of the typical surface plasmon resonance of gold nanoparticles around 520 nm and the characteristic π-π* transitions of the GQDs were observed. We demonstrate that these NHs can be used as a platform to electrochemically sense glucose. To make a thin film of NHs on conductive electrodes we used the electrophoresis technique (EPD). The electrode with NHs was then subjected to an oxidation/reduction cycle using glucose as a redox intermediate. We found that the current maintains a linear relationship in the concentration range of 0.5 mM to 10 mM, allowing for the determination of glucose concentrations within this range.

Graphene

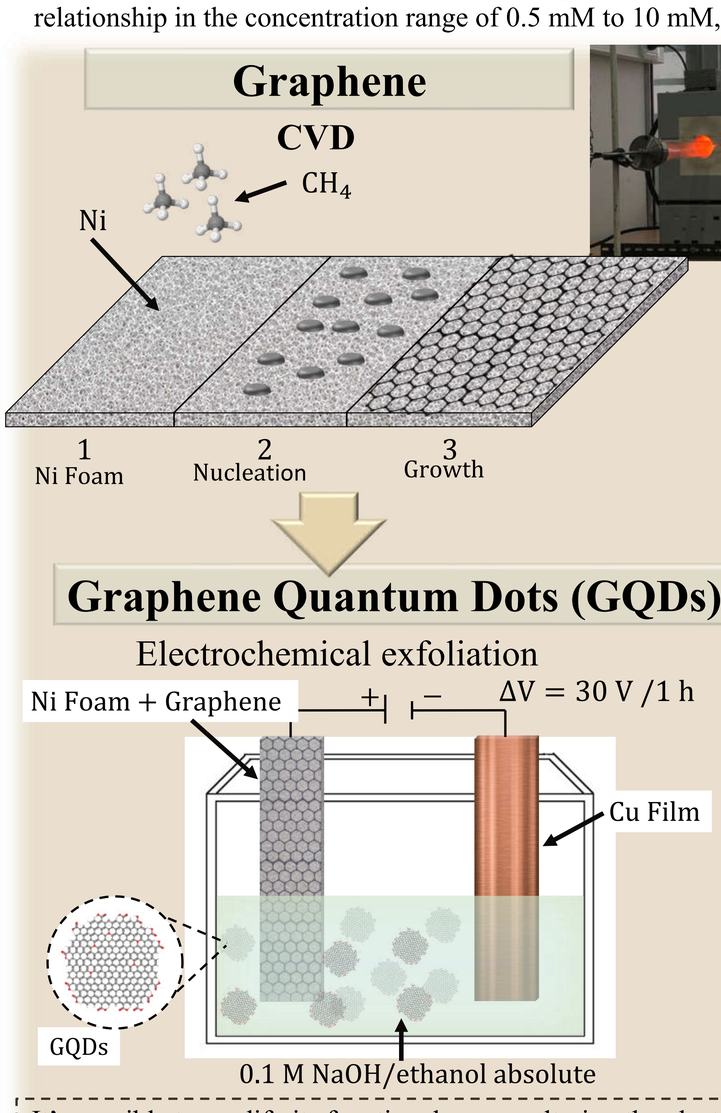
CVD





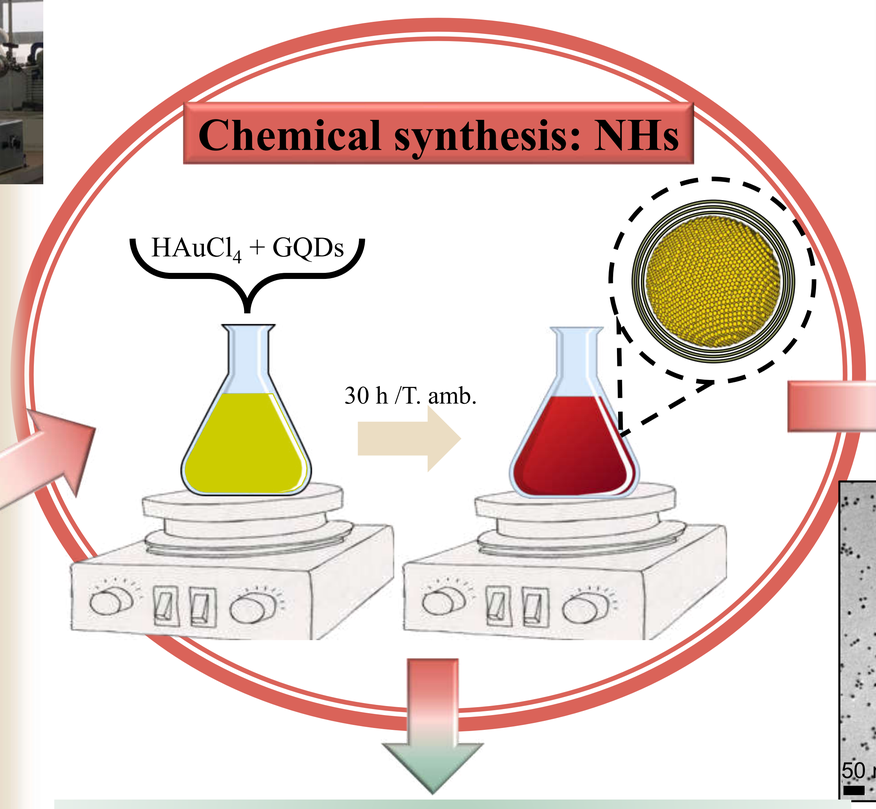
Graphene Quantum Dots (GQDs)

Electrochemical exfoliation



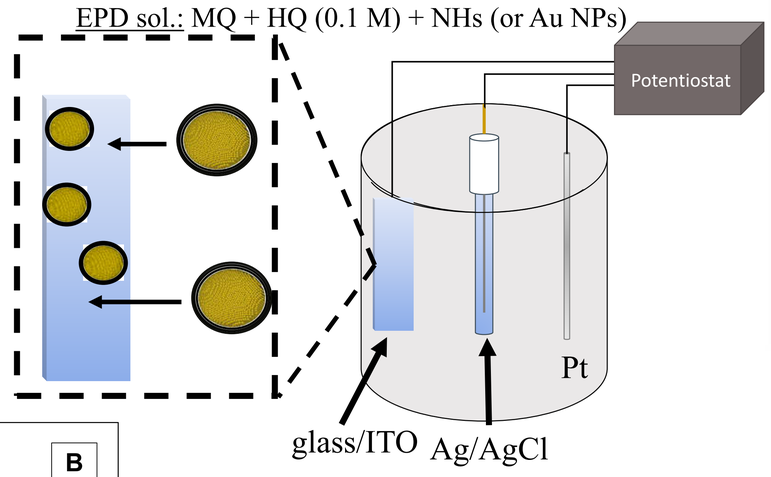
It's possible to modify its functional groups altering the electrolyte.

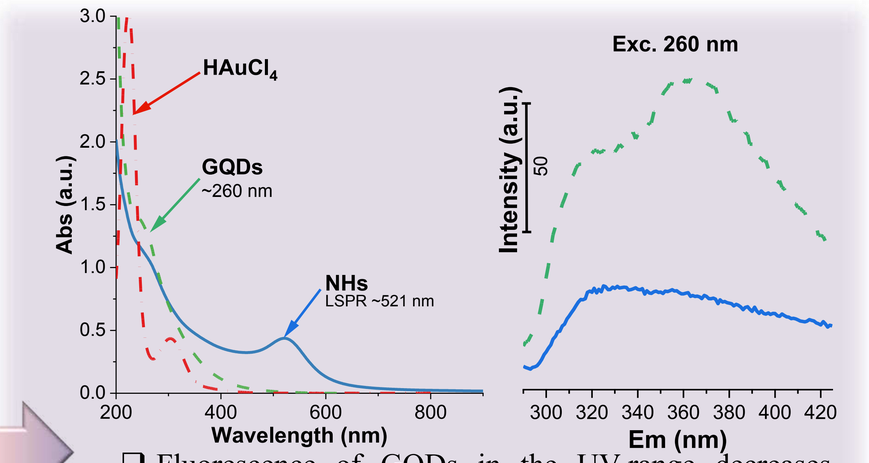
Chemical synthesis: NHs



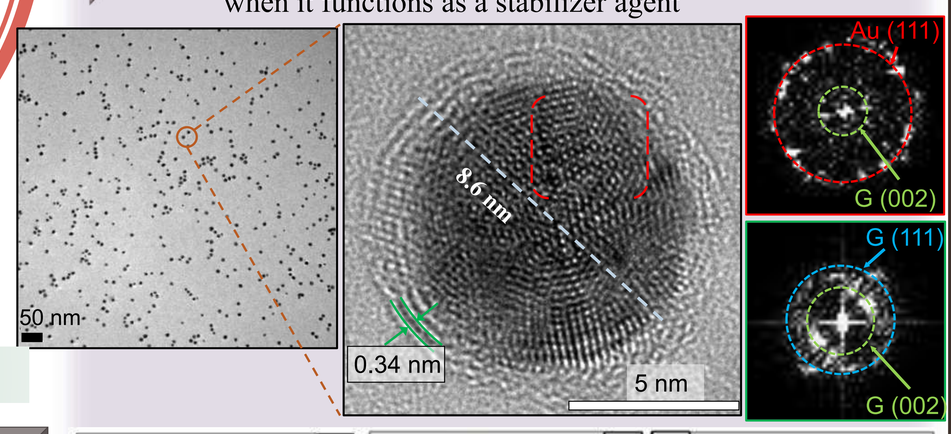
Film formation: EPD

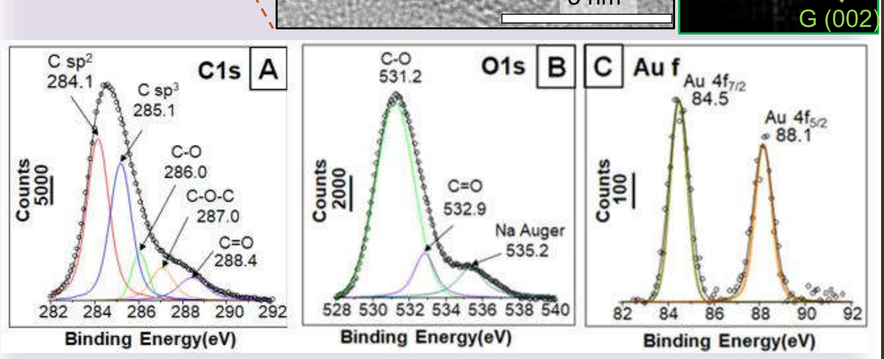
EPD sol.: MQ + HQ (0.1 M) + NHs (or Au NPs)





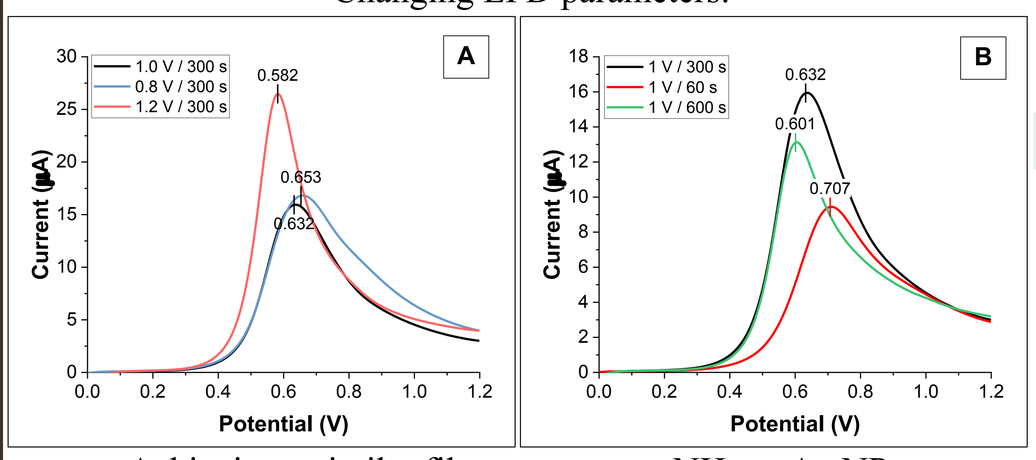
❑ Fluorescence of GQDs in the UV-range decreases when it functions as a stabilizer agent



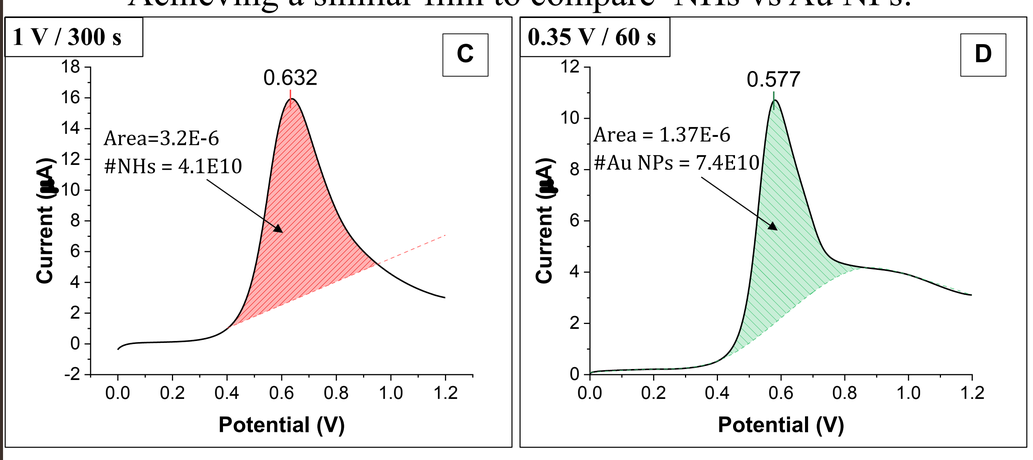


Film characterization: LSV

Changing EPD parameters:

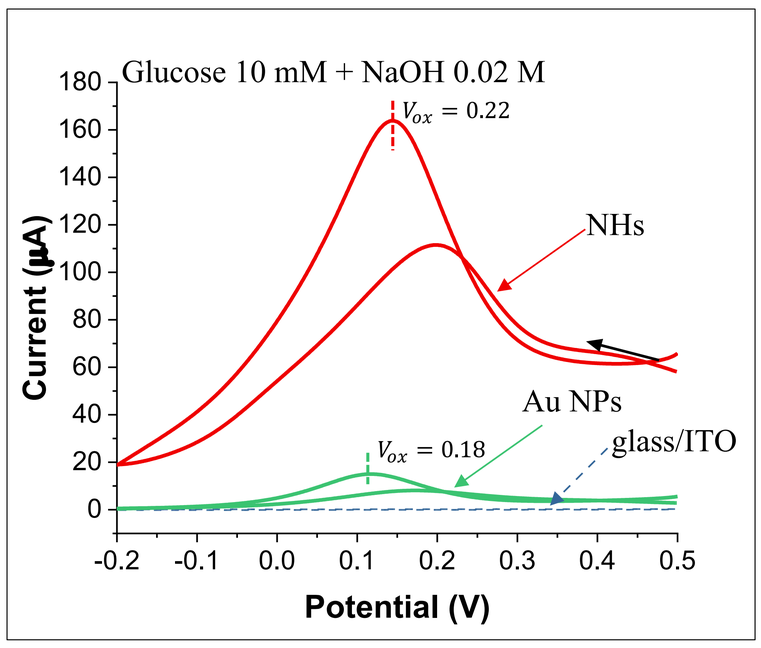


Achieving a similar film to compare NHs vs Au NPs:



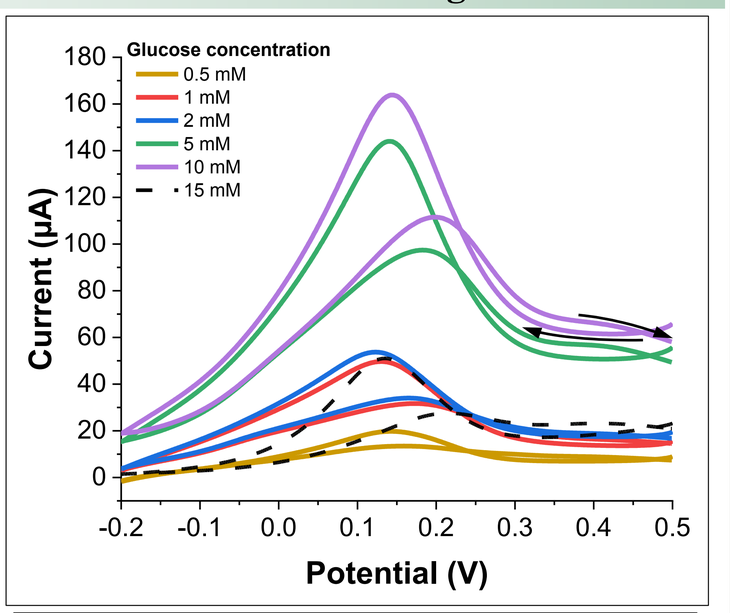
Catalytic activity towards glucose oxidation

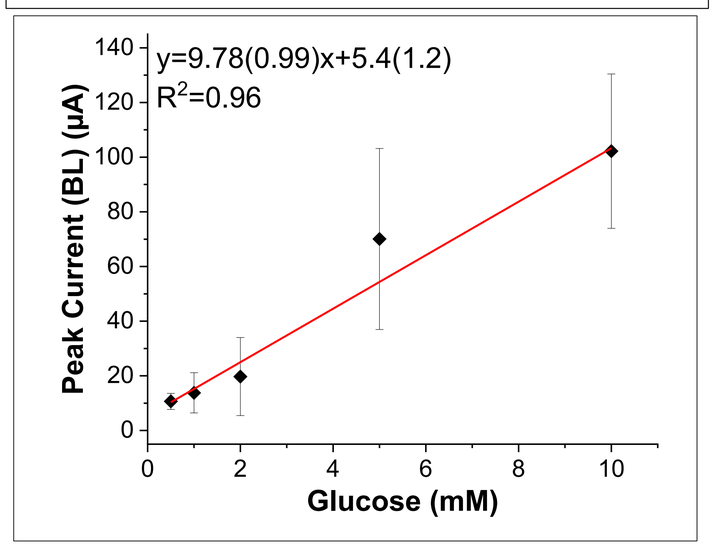
NHs (Au@Graphene) vs Au NPs (Au@cit):



❑ Higher current of the ITO/NHs catalyst is possibly due to the oxygen containing groups in the shell of the NH.

Glucose Sensing





Conclusions

- ❑ GQDs act as reducing and stabilizer agents for NHs chemical synthesis, in which we obtain Au/graphene core-shell nanostructures.
- ❑ Optimal EPD parameters for film formation were determined to be 1 V/300 s.
- ❑ When comparing the catalytic activity of NHs towards glucose oxidation with Au NPs (Au@cit) we obtain higher oxidation potential (less catalytic) but higher current, proving the better performance of the ITO/NHs films catalyst.
- ❑ For glucose sensing we measured the peak current of the CV when varying glucose concentration from 0.5 to 15 mM, achieving a linear relation with glucose concentration between 0.5 and 10 mM, when the normal range of glucose in human blood is 3 to 8 mM.

References