PROJECT TITLE

Modification of electrode surfaces with carbon nanoonions for biosensor applications

PROJECT SUPERVISOR

Name: Alex Fragoso

e-mail: alex.fragoso@urv.cat

Telephone: **+ 34 977 55 8579**

DESCRIPTION

Overview:

The project deals with the development of strategies for the immobilization of electrode surfaces with carbon nanoonions (CNOs) and their possible applications in biosensors.

Background and State of the Art:

CNOs[1] are a class of relatively low studied carbon nanostructures with potential applications ranging from catalysis to photovoltaic and fuel cell applications. CNOs are electrically conductive and possess a much larger surface area than single-walled carbon nanotubes (SWNTs) and are thus potential candidates for the development of miniaturized fuel cells and biosensors.[2]

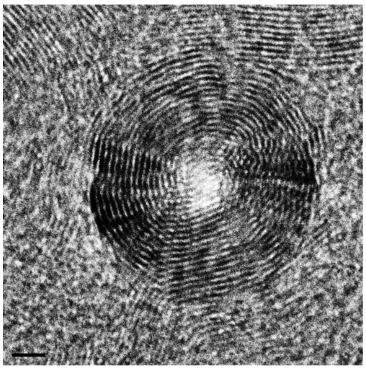

Fig. 1. HR-TEM image of CNOs. (scale bar = 2 nm).

CNOs are insoluble in organic and inorganic solvents, similar SWNTs. Therefore, the lack of solubility hindered study of their chemical and physical properties for many years, before the first solubilized CNOs were reported by functionalization via 1,3-dipolar cycloaddition of azomethine ylides containing polyethyleneglycol chains that rendered the modified CNOs soluble in organic solvents.[3]

CNOs have been incorporated into polydimethylsiloxane, polyurethane and polymethylmethacrylate matrices[4] and the electromagnetic properties of these materials were investigated. The preparation and electrochemical properties of a novel type of composite made of *small* carbon nano-onions (CNOs) with poly(diallyldimethylammonium chloride) (PDDA) or chitosan (Chit) were investigated by cyclic voltammetry and electrochemical impedance spectroscopy.[5] Composite films on glassy carbon electrode surfaces were deposited by a coating

---

[1] Ugarte, D. *Nature* **1992**, *359*, 707.
[2] Rettenbacher, AS. et al. *Chem. Eur. J.* ***2006***, *12*, 1521.
[3] Georgakilas, V.; et al *J. Am. Chem. Soc.* **2003**, *125*, 14268.
[4] a) O. Shenderova, et al. *Diamond Relat. Mater.*, **2007**, 16, 1213. b) J. Macutkevic, et al. *Diamond Relat. Mater.*, **2008**, 17, 1608.
[5] J. Breczko, et. al. *J. Mater. Chem.*, **2010**, 20, 7761.

method, applying a drop of solution containing the suspended CNOs and filler, PDDA or Chit. . The capacitance of the films is primarily related to the amount of CNOs incorporated into the layer of the filler. The composites also show a low relaxation time from resistive to capacitive behavior, therefore indicating that they can operate as capacitors in short time windows.

The first covalent functionalization of oxidized CNOs (ox-CNOs) with biomolecules, by using biotin–avidin interactions has been recently reported.[6] Multilayers were prepared on a gold surface by layer-by-layer assembly and the process was monitored by surface plasmon resonance (SPR) spectroscopy and atomic force microscopy (AFM). Covalent binding of molecules to the short amine-terminated organosulfur monolayers was assessed by Fourier transform infrared spectroscopy using total attenuated reflactance mode (FT-IR/HATR).

Methodology:

The project includes the following tasks:

1. *Obtention of stable CNO dispersions*. Several dispersing agents will be tested with the aim to obtain stable dispersions of CNO in water suitable for electrode modification.
2. *Modification of electrodes with CNO*. The dispersions will be castes on carbon and gold electrodes. The surface will be characterized by optical as well as electrochemical techniques (TEM, AFM, impedance, conductance, etc.)
3. *Preparation of new carbon nanoonion (CNO) cyclodextrin composites* (Figure 2). CNOs will be casted on electrode surfaces and modified with self-assembled CD/polymer structures. This surface will then be modified with a biorecognition element. and used in the development of electrochemical biosensors.

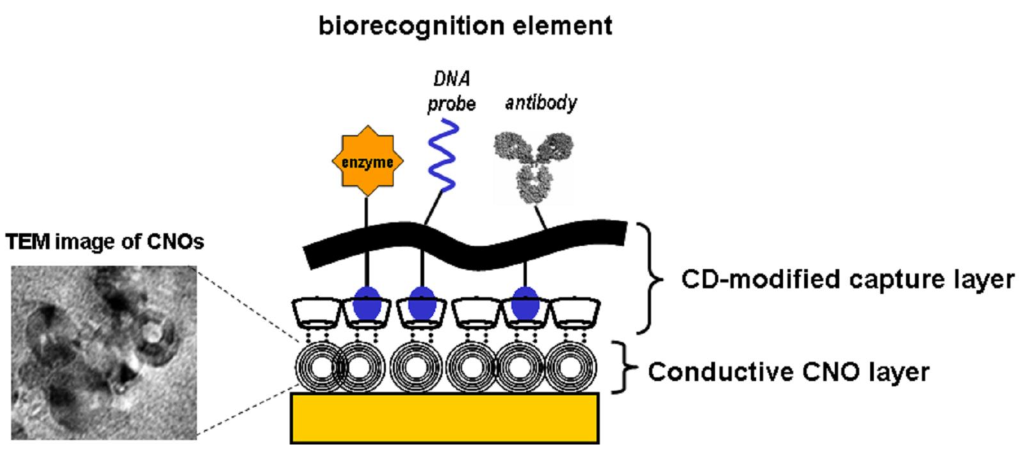

Figure 2. Biosensors based on carbon-nanoonion/cyclodextrin composites.

[6] J. Luszczyn et al. *Chem. Eur. J.* **2006**, *16*, 4870.