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A STUDY ON OF-THE-SHELF SCREEN-PRINTED CARBON ELECTRODES AS NITROGENOUS SPECIES DETECTORS

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Introduction

The presence of toxic levels of nitrates, nitrites, and ammonium in tap water poses a real threat to human health, especially to children. Fast detection of toxic thresholds requires access to affordable portable devices and cheap disposable electrochemical sensors achievable through the development of a simple fabrication process ready for mass production. Even with the transition towards screen-printed electrodes (SPEs), the modification route is still complex. Screen-printed Carbon Electrode (SPCE) is a promising solution as they have an extremely low price per unit and are simple to manufacture. We are investigating in this paper of-the-shelf general-purpose available sensors without any further modification to detect the threshold level of toxic nitrogenous compounds.

Materials and methods

The sensors studied were purchased from DropSens (Table 1). These disposable SPCEs modified with different nanomaterials are designed for the development of (bio) sensors with enhanced electronic transfer properties. For comparison reasons sensor DRP-C223AT based on gold only (with Ag RE) was tested. In addition, a sensor was developed in-house based on graphite ink (PE-C220 carbon resistive ink) and Ag pseudo-reference (PE-AG530 silver conductive ink) manufactured through screen-printing technique on a flexible PET substrate.

For electrochemical analysis, a portable potentiostat device was developed. The system contains a RF Duino processing unit connected to an LMP91000 potentiostat chip and a Bluetooth wireless communication interface. IoT compatibility is ensured by communication with a smart unit such as a smartphone, laptop, or tablet. In this sense, a web application has been developed for controlling data acquisitions and developing a Graphical User Interface (GUI). The communication protocol used to establish the connection from the potentiometer to the application is Bluetooth Low Energy also known as Bluetooth 4.0. The web application is hosted on the Firebase hosting service same as the database for this system.

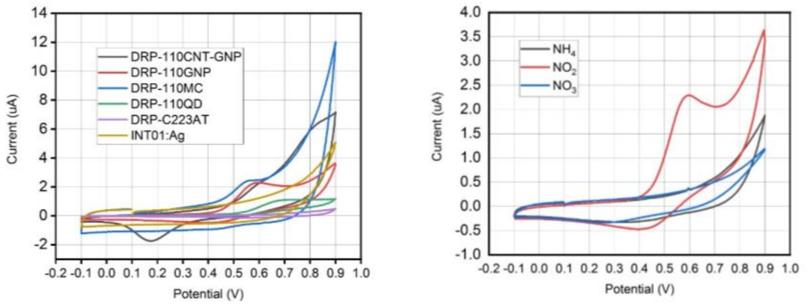
Table 1. Characterization of the sensors

IDENTIFIER	WORKING ELECTRODE (WE)	AUXILIARY ELECTRODE (AE)	PSEUDO-REFERENCE ELECTRODE (RE)
DRP-110CNT_GNP	CNT-GNP / Carbon*	Carbon	Silver
DRP-110GNP	GNP / Carbon*	Carbon	Silver
DRP-110MC	MC / Carbon*	Carbon	Silver
DRP-110QD	CdSeQD/Carbon	Carbon	Silver
DRP-C223AT	Gold	Gold	Silver
INT01:AG	Graphite	Carbon	Silver

*CNT-Carbon Nanotube; GNP-Gold Nanoparticles; MC-Mesoporous Carbon; QD-Quantum Dots

Results and conclusions

To determine the affinity and selectivity of the sensors analyzed for the three analyzes, they were exposed to the same concentration of 1 mg / L of each analyte, *via* cyclic voltammetry, with potentials running from -0.3 V to 0.9Vand Srate 0.03 V/s. The recorded plots showed a good reaction of the sensors to NO_2, but little to no reaction to NH_4 and NO_3 (Figure 1a). In the presence of NO_2, the 110MC has a maximum oxidation peak at 0.55V and 110GNP at 0.6V, respectively. Such good sensitivity can be attributed to the efficiency of the electron-transfer between the modified electrode and nitrite due to the catalytic effect and low charge transfer resistance of MC and GNP/Carbon.



a) b)

Fig.1: Cyclic voltametry a) response to NO_2; b) sensor DRP-110GNP selectivity to 1mg/L NH_4, NO_2, and NO_3

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