

Surface Modification with Prussian Blue to Screen-Printed Electrodes for Sodium Detection in Soil Extracts

Erika Bustos¹, Víctor Julián González-Nava¹, Sara Solís-Valdéz², Selene Sepúlveda-Guzmán³, Juan Manríquez¹, Angela Stortini⁴

¹Centro de Investigación y Desarrollo Tecnológico en Electroquímica, S. C. Parque Tecnológico Querétaro s/n, San Fandila, Pedro Escobedo, 76703, Querétaro, México.

²Geoscience Center, Universidad Nacional Autónoma de México, Campus Juriquilla, Blvd. Juriquilla 3001, Querétaro, 76230, México.

³Faculty of Mechanical and Electrical Engineering, Universidad Autónoma de Nuevo León, Ciudad Universitaria, Pedro de Alba s/n, San Nicolás de los Garza, Nuevo León, 66455, México.

⁴Department of Molecular Sciences and Nanosystems, Ca' Foscari University, Dorsoduro 3246, 30123 Venice, Italy.
ebustos@cideteq.mx

Screen-printed Carbon electrodes with Carbon Nanotubes (CCNT) with and without modification with Prussian blue (PB) have been evaluated to detect sodium in solution; in addition, the importance of studying these electrodes to carry out field tests in the future without leaving aside its simple synthesis and at the same time affordable for the detection of sodium in soils. The presence of salts affects the assimilation of nutrients by plants and microbial activity [1]. Soil salinization and sodification are critical soil degradation processes that threaten ecosystems and are recognized as one of the most essential problems globally for agricultural production, food security and sustainability in arid and semi-arid regions. When Na⁺ is the determining cation, the dispersion of the clays occurs, which leads to the destruction of the structures, in addition to causing a dispersion of the soil colloids, which makes it much less permeable [1].

Conducting the electrochemical study and characterization of the deposits was necessary to understand their interaction, stability in solution, and the reliability of the readings from actual soil extract samples, in addition to the use of cyclic voltammetry and amperometry techniques for the construction of sodium calibration curves for subsequent analysis. Nanostructured compounds of PB as electrocatalyst over CCNT can be applied as electrochemical detectors, which is a cubic coordination complex centered on its faces, generating empty spaces through which ionic chemical species can melt, transferring charge between the Fe³⁺ and Fe²⁺ ions through cyanide that binds them (-C≡N-) [2-4].

The sodium in actual samples of aqueous soil extract was measured using the calibration curve (current density as a function of sodium concentration). The areas found were 5.77 x 10⁻⁵ cm², 9.02 x 10⁻⁵ cm², and 8.80 x 10⁻⁵ cm² for C, CCNT, and CCNT-PB, respectively. The electroactive area of the electrodes is essential for their modification; PB was electrodeposited between the CNTs and/or on them, so the electroactive area found in this type of electrodes (CCNT-PB) is slightly less than the CCNT electrodes. However, despite having a smaller area, the deposit helped obtain a better signal in detecting sodium than simply having CNT on the surface of the electrode. The results obtained using the CCNT-PB electrode for detecting Na⁺ in the natural soil extract samples were 2.80 and 3.64. 2.45, 4.01, 3.30, and 3.45 cmol/Kg soil. Additionally, the C, CCNT, and CCNT-PB surfaces were characterized by XRD, SEM-EDS, and Raman spectroscopy, showing the presence of PB as cubic shapes around the CNT, which is the electrocatalyst to promote the best detection and quantification limit of sodium in aqueous media for this research.

REFERENCES

- [1] Piedra L. A., Cepero G. C. C.M, (2013), *Cultrop* vol.34 no.4 La Habana, ISSN 0258-5936.
- [2] B. T. T. Nguyen, J. Q. Ang and C. S. Toh, (2009). *Electrochemistry Communications*, 11, 1861. <http://dx.doi.org/10.1016/j.elecom.2009.08.003>
- [3] R. Yang, (1998). *J. Electrochem. Soc.*, 145, 2231. 10.1149/1.1838625
- [4] S. Husmann, S. G. Booth, A. J. G. Zarbin and R. A. W. Dryfe, (2018), *J. Braz. Chem. Soc.*, 29, 1130. <http://dx.doi.org/10.21577/0103-5053.20180024>